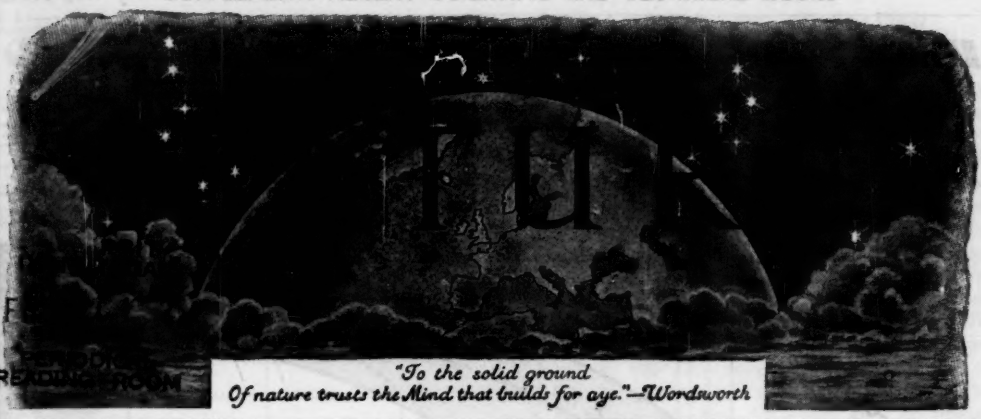

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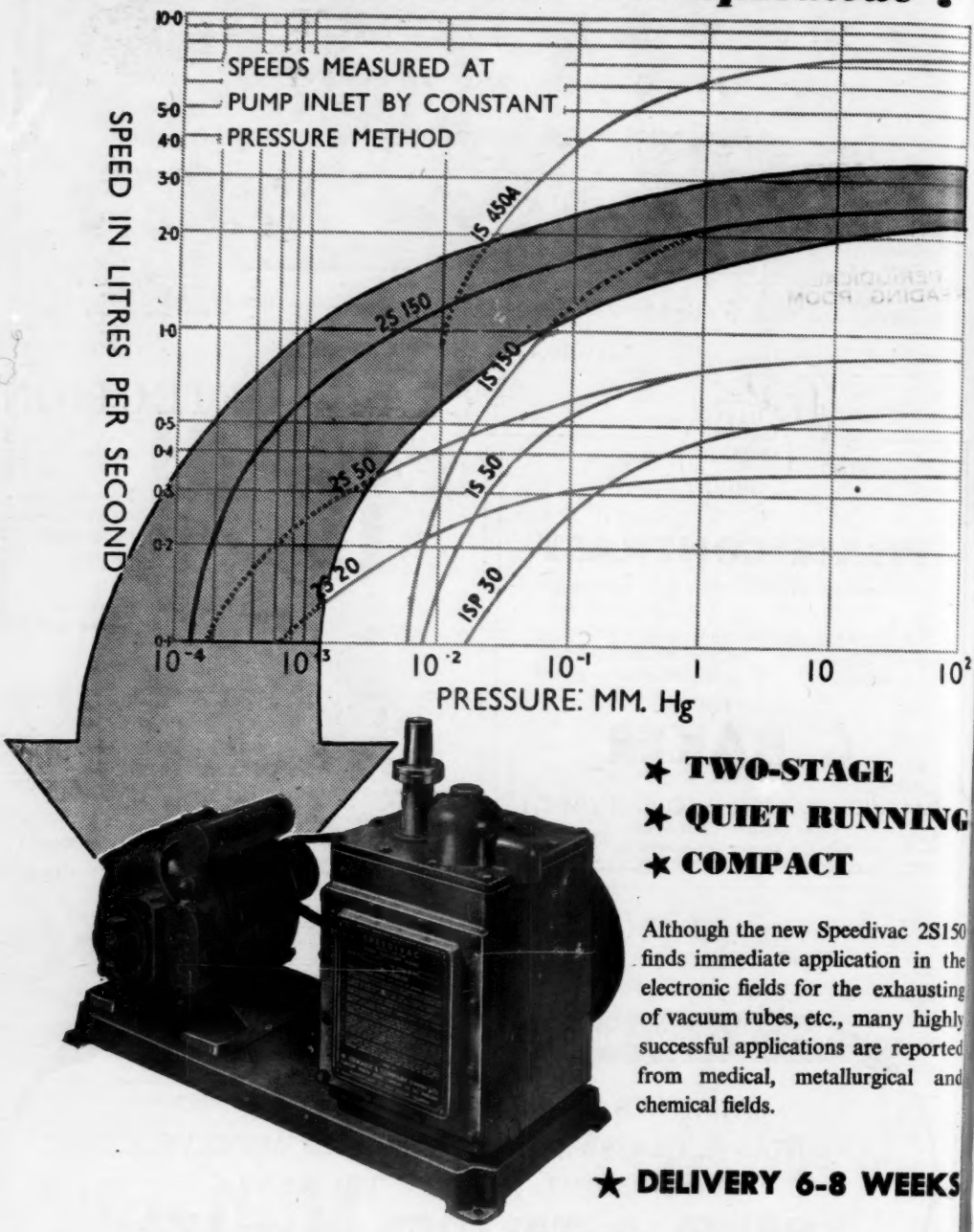

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EXPANSION OF SCIENTIFIC RESEARCH AND DEVELOPMENT

IT is generally accepted that the range and quality of fundamental research in Great Britain are satisfactory, even in comparison with the impressive output of the United States. Nevertheless, its scale requires augmenting, and considerably greater financial resources should be made available for the support of pure and applied scientific research in the universities and in the technological institutions. A 'productivity team' sent out a year ago by the Anglo-American Council on Productivity estimates that university expenditure in Britain on scientific research is £1·5 millions ; if we add the most generous estimates for the proportion of the expenditure of £141 millions on research and development in the Civil Estimates for 1951–52 which goes to fundamental research, and for industry's own expenditure on such research, the total is still likely to be far below the 110 million dollars of the United States. The comparative man-power situation is equally important. Dr. H. Vagtborg, during the International Conference on the Organization of Scientific and Industrial Research, gave no figures for scientific and technical staff in Federal Government service and did not distinguish such staff in the total which he gave for some five representative research institutes (excluding the Mellon Institute). He estimates, however, the research staff in industry as 165,000, of which 70,000 are professional and 40,000 technical. It will be recalled that the Industrial Research Secretariat of the Federation of British Industries estimated in 1947 that in Britain about 45,000 persons were employed directly on industrial research and development in industry, about 10,000 of whom were professionally qualified, and that British industry expended about £30,000,000 annually on research and development within its own establishments.

Those figures have since been scaled up, as the report on chemical industry from the Association of British Chemical Manufacturers showed two years ago ; but it is evident that the productivity of American industry is related to the existence of this much more numerous scientific and technical staff, and particularly the readier assimilation of new ideas and application of new discoveries, and generally the more integrated approach to industrial problems essential for achievement in industrial research. Apart from this, there are deficiencies in the actual range of research effort in Britain. Dr. P. F. R. Venables has emphasized the lack of technological research in Britain and its importance in regard to technological education rather than to production. Still more recently, the report of the Committee on Chemical Engineering Research* has pointed to a marked gap in a field in which the universities and technological institutions are still unable to supply the country with the full number of trained graduates required.

Disregarding here the valuable list the report contains of specific problems on which research is

* Department of Scientific and Industrial Research : Advisory Council. Report of the Committee on Chemical Engineering Research. Pp. iii+36. (London : H.M. Stationery Office, 1951.) 1*s.* 6*d.* net.

required, it is sufficient to point to the emphatic conclusion of the Committee that the existing facilities for the prosecution of chemical engineering research are inadequate for the purposes of the chemical and allied industries as a whole. The synthetical approach to plant design, based on investigations of the mechanism of the basic or unit operations employed in industry, could probably be met sufficiently by expanding existing facilities in universities and colleges of technology. For the analytical approach—the provision of data, based on large-scale operation, for design purposes—the Cremer Committee regards existing facilities as entirely inadequate.

This situation, in the opinion of the Cremer Committee, has been one factor which has favoured the development in other countries of processes originating in Britain, both by increasing efficiency or productivity or by facilitating the utilization of a new discovery. It is as a step towards increasing productivity and the utilization of scientific discoveries that the Committee recommends supplementing existing facilities for research in this field by a central organization specially adapted or created for the purpose.

A very similar suggestion was made in the report of the Association of British Chemical Manufacturers on the chemical industry, and has also been made in connexion with university expansion. The proposal clearly requires consideration simultaneously with the proposal to establish a new technological institution of university rank which it is understood is being re-examined by the present Government. There might be advantages, besides financial economy, if the two proposals could be combined in some way, notably in encouraging technologists and scientific men trained in one field to work with those trained in others, and in preventing the establishment of mutually exclusive disciplines. However much it may be necessary to include in technological education some elements of humane and social studies—in public life as well as in industry—the bringing together of a wider range of disciplines and technologies in one institution is a valuable aid to developing a wide outlook. Although this report has been presented in the first instance to the Advisory Council for Scientific and Industrial Research, its general proposals are thus related to the whole question of technological education at present under consideration by the Minister of Education. Indeed, this report, like that of the 'productivity team' on universities and industry (see *Nature*, January 5, p. 1), should be duly considered by the Minister in that connexion and, it might be added, by the Lord President of the Council, the Advisory Council on Scientific Policy and the University Grants Committee.

What is most evident from the 'productivity team' report on the relations between the universities and industry in the United States is that the organization of scientific and technological research is closely related to the teaching of science and technology, quantitatively and qualitatively. In range and flexibility, British institutions compare favourably with those in the United States; where they fall short is in scale, and notably in technology and in chemical engineering generally. Much the same impression is to be derived from the reviews of the position in France, in Sweden and in the Federal German Republic which were presented at the recent International Symposium on the Organization of Scientific and Industrial Research.

It cannot be said that the report of the 'productivity team' on the universities and industry gives any clear lead as to the form which the overdue expansion of technological education in Great Britain should take. In some respects American institutions are changing and taking a shape nearer those in Great Britain, and Prof. R. S. Edwards's plea that we should trust our own genius and develop or invent for ourselves rather than copy those of others has been cogently argued.

The evidence now accumulated as to the importance of the contribution which such expansion could make to productivity is impressive enough to sweep aside the timidity which characterized the White Paper of September. The imperative need for due economy should ensure that such expansion is planned with full regard to the needs of the universities and the teaching and research in their scientific departments. The report from the 'productivity team' on education for management has provided simultaneously a reminder that such expansion should be in balance with the general studies of the universities, and that full regard must also be had to the work of the technical colleges in providing industry with the technicians which are needed in ever greater numbers. It is clear that such expansion has to be considered also in the light of its direct contribution to the facilities and organization for scientific and technological research generally. There can no longer be any excuse for vacillation; whatever other action is taken, the responsibility for the general oversight of university and higher technological education should be placed unambiguously on the shoulders of a single competent authority able to take long views and strong enough to secure the flexibility and independence which are essential for freedom of experiment with new institutions or the modifications of existing ones. Those are the conditions of creative work in science, and also in other spheres like that of administration, and it is along such lines that the genius of Great Britain has made its most characteristic achievements.

MEMORIES OF A VETERAN

Cambridge and Elsewhere

The Memories of Sir William Cecil Dampier. Pp. x+150+8 plates. (London: John Murray, 1950.) 10*s.* 6*d.* net.

WHEN the Senior Fellow of Trinity, who has known Cambridge for sixty-five years, writes his reminiscences, we look for stories of the men who made Cambridge history near the beginning of the present century. We do not look in vain; but we could wish that more than one chapter had been devoted to that subject and that fuller pictures had been given of the Cambridge personalities of bygone days. We welcome the picture of Sedley Taylor

rubbing his hands on his knees in enjoyment as he told a good story; but to complete the picture we ought to have been told also of his flapping his arms in his excitement over the final joke. From one with so long a connexion with the Cavendish Laboratory, as Whetham had before he became Sir William Dampier, we might have hoped to hear some tales of Thomson and Rutherford as well as an account of their scientific work.

Having expressed regret that one side of this book has not been developed as fully as we could have wished, we turn to more fully described elements of the author's long and varied life. First, we may mention his life-long interest in country life and agriculture. Learning in boyhood to hunt and to shoot, he continued those sports in Cambridge, and in a sense combined them by serving in the Mounted Infantry Unit of the University Volunteers. In the First World War, after valuable service on the committee dealing with applications for commissions and after carrying out such duties as guarding railway bridges at night, he joined the Food Division of the Ministry of Agriculture. He inherited landed property in 1916, and changed his name from Whetham to Dampier; in the country he took to dairy farming and cheese-making. Later he developed a new industry producing lactose from whey: a process which (under United Dairies, Ltd.) produces each year thousands of tons of lactose from millions of gallons of whey, started in a cart-shed on his farm at Hilfield in Dorset. Sir William Dampier was the first secretary of the Agricultural Research Council and received the Gold Medal of the Royal Agricultural Society for his services to agriculture. For many years he acted as chairman of the Cambridgeshire Rural Community Council.

Other activities and interests are indicated by the titles of some of his books. "The Family and the Nation" indicates the great interest that he took in the subject of heredity: "A History of Science and its Relations with Philosophy and Religion" shows a separate approach to the problems of the day. We should like to have heard more about the author's views on the relations between science and religion than he gives in this book. Naturally, he gives an account of his own research work and of his experiences as a teacher.

On the more human side he gives a short account of his work as a college tutor. One sentence stands out: "I remember one disastrous fortnight when one man went off his head, another fell from his pony playing polo, two were dangerously ill, one ran away alone, and one ran away—not alone".

Clearly the varied duties that came his way called for a wide range of inherited qualities from his ancestors to make their successful performance possible. One is not surprised to find in the Whetham and Dampier families a lord mayor of London, a bishop, a judge and a buccaneer—for so John Evelyn describes Captain William Dampier. The present Sir William Dampier prefers to call him "the Navigator": if this suggests a certain sense of proper dignity, let us restore the balance by saying that his sense of humour allows him to quote a savage attack by William Cobbett on the family of Dampier, as maintained at the public expense: "I would pledge my existence, that they are, in some shape or other feeding upon the public. However, thus it must be, until that change come, which will put an end to men paying fourpence in tax upon a pot of beer". Alas, that change has come! F. J. M. Stratton

CATALYSTS OF CELLULAR ACTIVITY

The Vitamin B Complex

By F. A. Robinson. Pp. xi+688. (London: Chapman and Hall, Ltd., 1951.) 60*s*. net.

THE demise of the science of organic chemistry has been confidently predicted at intervals during the last half-century; but it has confounded the prophets by its abiding vitality. Organic chemistry has been sustained and revivified by remarkable developments in the chemistry of natural products and biologically active synthetic compounds, and by the advances made in our understanding of the reactions of organic compounds. In some respects the most romantic of the dramatic episodes in twentieth-century organic chemistry has been that concerned with the unfolding of the story of the vitamins. Most of this story belongs to the second half of the half-century. Before then the vitamins were described somewhat vaguely as fat-soluble vitamins A and D, and water-soluble vitamins B and C. Now their chemistry is largely complete. Probably all the important vitamins have been recognized; they have been isolated and characterized, and most of them have been prepared synthetically. Indeed, in several cases the synthetic vitamins are available commercially. An interesting reversal of the usual sequence has taken place with riboflavine, where synthetic manufacture has been supplanted by a process of isolation from natural sources. It appears that riboflavine can be produced more cheaply by a fermentation process.

Dr. F. A. Robinson's book deals only with the chemically diverse water-soluble compounds which constitute what is known as the vitamin B complex. He is well qualified to write on this subject, and the book has the stamp of authenticity with its comprehensive survey of the whole body of knowledge of the individual members of the vitamin B complex. Each section has an extensive bibliography, and the authority is quoted for nearly every statement made. In his concluding paragraph the author writes: "I can only express the hope that my attempt to systematize the large mass of information now available will have given the reader a clear picture of the chemical and biological behaviour of each member of the vitamin B complex, and an appreciation of the important function the group as a whole performs in the economy of mammals and birds, insects, plants and micro-organisms". Dr. Robinson has admirably fulfilled this purpose, and all who are interested in any aspect of work in this field will be grateful to him for his valuable reference book, and for the time and care which he has expended in its preparation. Even while it was being written, important advances were made; and, although there is a chapter on vitamin B_{12}, the more recent work on its chemistry is not reported. This is, perhaps, the most serious omission.

The material is portrayed in an orderly and systematic way. For the most part, each chapter is devoted to a single vitamin, and is divided into some 18–20 sections dealing with such aspects as the early work leading to the isolation of the vitamin, the determination of its structure and its synthesis, methods for its biological assay and chemical estimation, the metabolism and pharmacology, the nutritional requirements in various species, the deficiency symptoms and the biochemical function. Many of

these sections are further subdivided under suitable subheadings.

Dispersed through the book are fascinating accounts of the catalysis of various biochemical processes by enzymes, of which the various vitamins form essential components. Chapters are devoted to *meso*-inositol and choline, which are regarded as occupying an intermediate position between the vitamins and the amino-acids, as regards both abundance and function. Attention is directed to the paramount importance of aneurine, riboflavine and nicotinic acid for human and animal nutrition. It is of interest that the terminal 'e' is now favoured for the names of the first two of these and also for pyridoxine, in conformity with their character as bases.

There is an interesting discussion of the significance of the biological interchangeability of nicotinic acid and tryptophan, and of the possible biosynthesis of the former from the latter. It is suggested that vitamins B_3, B_4 and B_8 are of historical interest only, and attention is directed to the fact that B_7, B_8 and B_9 have never existed. This makes the designations vitamins B_{10}, B_{11}, B_{13} and B_{14} for some recently reported nutritional factors a little misleading; but in a subject of such confused origins some anomalies in terminology are inevitable.

Although this is by no means the only modern book on vitamins, it seems clear that it will be regarded for some time to come as the standard of reference on the vitamin B complex. J. W. Cook

A NEW SURVEY OF HEAT AND THERMODYNAMICS

A Treatise on Heat (including Kinetic Theory of Gases, Thermodynamics and Recent Advances in Statistical Thermodynamics)

By Prof. M. N. Saha and Dr. B. N. Srivastava. Third edition, thoroughly revised and rearranged. Pp. xii+936. (Allahabad and Calcutta: Indian Press, Ltd., 1950.) 32 rupees.

ONE is sometimes inclined either to be unaware of, or to under-estimate, the scope of thermodynamics and the great variety of problems which are amenable to treatment by its methods. It is therefore refreshing to read the new edition of this well-known text-book, especially the latter half, which contains much new material and has been extensively revised.

The twenty years since the first edition appeared have seen a much more extensive application of statistical thermodynamics to specific heats, to low-temperature phenomena and many other solid- and liquid-state phenomena, to chemical equilibria, ionization, thermal diffusion and to astrophysical problems, a list which is by no means exhaustive.

The third edition of the book not only discusses all these, but also, in the earlier chapters, treats the conventional and classical parts of the subject. The initial treatment is elementary, so that the book is suitable for all levels of university teaching, from first year to graduate study. In view of the rapid increase in knowledge it is a difficult feat to survey and treat a whole subject from its beginnings up to the boundaries of knowledge in one volume; but, on the whole, Prof. M. N. Saha and Dr. B. N. Srivastava have succeeded very well indeed. The book is a pleasure to read, not only from the clarity of its style but also from the obvious enthusiasm with which it has been written.

Most of the criticism which may be made against it is on personal grounds of preference and emphasis rather than of substance. There is, for example, a good deal of elaborate description and discussion of early experiments on heat which have now only limited value. One exception, however, can be made. In this, and I think in all other text-books on heat, the Bunsen ice calorimeter is dismissed as unreliable and of historical interest only, when in fact it is being extensively used as an accurate and reliable instrument in the United States, particularly by the National Bureau of Standards.

Again, in one part of the book there is a curious sequence of subject-matter. Heat engines and their theory come in Chapter 4 before any discussion of the first and second laws of thermodynamics, which are treated in Chapters 5 and 6 respectively. It is not clear why this order should be chosen, since in Chapter 4 the reader is more than once advised to read the two following chapters before proceeding. It is also a pity that modern heat engines, such as the gas turbine and jet engine, should be dismissed in a dozen lines or so.

The practical treatment of refrigeration and the liquefaction of gases is very good indeed; but little mention is made of the importance of the concept of entropy in understanding the production of low temperatures, and the discussion of the third law of thermodynamics is somewhat limited.

The rest of the book is excellent. In particular, the chapters dealing with statistical mechanics, kinetic theory and vapour pressure, and radiation are to be commended. Appropriately enough in a modern monograph on heat, the last two words in the text are "atom bomb". J. F. Allen

PHYLOGENY OF FLOWERING PLANTS: FACT OR FICTION?

Families of Dicotyledons

By Alfred Gundersen. With Introductory Chapters by Chester A. Arnold, Oswald Tippo, Theodor Just, Herbert F. Copeland, J. Herbert Taylor and W. H. Camp. (Plant Science Books, Vol. 25.) Pp. xviii+238. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1950.) 4.50 dollars.

IN the ninety-two years since the publication of the "Origin of Species" a great deal of argument but remarkably little fact has been produced about the relationships of the Angiosperms. Two works, "Genera Plantarum", by Bentham and Hooker, and "Die natürlichen Pflanzenfamilien", by Engler and Prantl, both of undoubted value, but without the least trace of phylogenetic pretensions, have appeared. Afterwards the readers of these great works have often assumed, in spite of the facts, that they represented the views of their authors on phylogeny, and much of the argument has centred rather fruitlessly around this assumption.

Meanwhile, neither palæobotany, morphology, anatomy or cytology has thrown any light on the origin of the Angiosperms or of any major group within the Angiosperms which the unbiased observer can regard as unequivocal. Indeed, one may go further and say that no more is known now about the origin of any major group of plants than was known in 1859.

It is difficult, if one keeps an open mind, to avoid thinking that all the major groups had an exceedingly remote and perhaps more or less contemporaneous origin, and that the geological record, as at present known, reflects variations in the kinds of plants which grew in localities where preservation was possible and, to some extent, the successive dominance of different groups. The fact that no Angiosperms are known from the Palæozoic surely does not mean, in view of their diversity in the Mesozoic, that they did not exist then, but that they did not happen to be preserved. Even now, when they are the dominant group, the great majority of them perish without trace.

Dr. Alfred Gundersen, like Dr. J. Hutchinson before him, has, however, taken the view that it is possible to make out relationships between the different orders of flowering plants. He has provided more material for those who like arguing about such things, and he is to be congratulated on going outside the traditional limits of systematics by taking into account most of the attributes of plants in framing his classification. In brief introductory chapters experts deal with such topics as wood anatomy, cytotaxonomy and plant geography, and these features are used in the accounts of families which form the main bulk of the work.

This book, like the recent one by Dr. Hutchinson, performs a valuable service in stressing the fact that some of the main criteria in traditional classifications, for example, the distinction between Archichlamydeæ and Metachlamydeæ, are largely matters of convenience. But from the practical point of view convenience is a great merit in a classification, and from the prevailing lack of evidence it would seem that the time is not yet ripe, if indeed it can ever become ripe, for the abandonment of the old systems, though they may with advantage be modified to a limited extent.

So far as the origin of species is concerned, we have travelled a considerable distance since the time of Darwin; but very few new facts about the origin of orders have come to light, and we may agree more whole-heartedly than ever with the statement that "the origin of flowering plants is an abominable mystery".

T. G. Tutin

GROWING-UP IN SCHOOL

Studies in the Social Psychology of Adolescence

By J. E. Richardson, J. F. Forrester, J. K. Shukla and P. J. Higginbotham. (International Library of Sociology and Social Reconstruction.) Pp. x+266. (London: Routledge and Kegan Paul, Ltd., 1951.) 21s. net.

IN the past four decades, adolescence has had a good press. Novelists, playwrights, educationists, psychologists, psychiatrists, preachers and magistrates have described the hopes and fears, the wayward and steadfast conduct, of the 'teen-ager', and the cult of youth has led to spectacular results, at times catastrophic. But whereas half a century ago writers could assert, perhaps a little smugly, that growing up necessarily involves a period of storm and stress, to-day many people ask how far these disturbances are caused by mental or bodily factors incidental to maturation, and how far the barriers which the adolescent tries to respect or surmount with different degrees of success have been erected by society.

One result has been to stimulate inquiry into the structure of extant societies in which growing-up is less painful than in the European or American communities upon which the majority of social studies have been focused. Are there groups without a well-marked period of adolescence?

In one sense, conflicts appear adolescent only if the causal factors in the situation are envisaged by adults. Teen-agers are men and women if required for National Service, but not if they wish to vote in elections.

Study has recently been directed upon adolescence from new directions. Psychoanalysis and its derivatives, social anthropology, sociometry, and the qualitative investigations of the relations between small groups are examples. Study of group tensions is important, for the adolescent often exhibits ambivalent behaviour towards his elders. Even his maleness is usually exhibited in ways which are canalized by the social structure in which he lives. Types of misbehaviour and the labels given to them may reflect his social or economic status. While to-day co-operation is urged in many quarters, and team-games encouraged or enforced in schools, pupils may still regard their intellectual work as private and personal. In this section of the school-world man is an island unto himself. How, otherwise, could he reasonably be certain of a scholarship to the universities? What bright essayist in a school would want to pool his best ideas with a discussion-group? But this is a rhetorical question. The answer, so far as one school is concerned, is given in the present book.

Adults, whose school success was undoubted, sometimes admit that they liked a subject, not only for itself, but also because of friendly relations in the group which studied it. Some confess that it was the teacher they really liked, and believe that a change of teacher might have had results damaging or beneficial.

Problems like these, until recently the subject of speculation and anecdote, have been studied by the authors. Using methods derived from Moreno and Lewin, they have investigated the life of school pupils. They have tested, for example, the possibility of improving English composition by free group discussion. Under ordinary class-room discipline, not only does one pupil speak at a time, but also the teacher's eye has to be caught, and some mental mechanisms, not all of them pathological, render a few children too 'shy' to try this feat.

Adolescent attitudes towards religion and elders were examined. An interesting question arises, whether the standard text-books reporting a general adolescent tendency to revolt against parental opinion have not been based upon the United States, where, on the whole, the parents expect it. In Britain some children take this attitude, whereas others feel there may be something in what parents say. But are there types of attitude, depending upon early relations towards one or both parents?

One reason for carrying out this investigation, which concentrates more upon results than upon theory, is that it would help teachers to know the mental pictures which boys and girls have of themselves. What are their respective levels of aspiration, and do they think they can achieve them? Or have they long ago, in an attempt to be realistic, lowered their sights?

As the authors fully acknowledge, some of the methods used raise problems of their own. But since children learn in groups, it is good that group relations should be better understood.

SOME ENZYMES OF ISOLATED CELL NUCLEI

By V. ALLFREY, H. STERN and Dr. A. E. MIRSKY
Laboratories of the Rockefeller Institute for Medical Research, New York

IN a study of the enzymatic activities of cell nuclei, the results of which are briefly given in this communication, we have isolated nuclei by a procedure not commonly employed, namely, fractionation in non-aqueous media. Emphasis is placed upon the method because recent studies of intracellular enzyme distribution have been concerned almost exclusively with histochemical tests of doubtful validity[1], or with cell fractions isolated by differential centrifugation in citric acid or sucrose solutions (for recent reviews see refs. 2 and 3). Results obtained in this laboratory and elsewhere[4] indicate that cell nuclei prepared by such 'homogenization' techniques in aqueous media are ill adapted for studies of enzyme localization in the nucleus. This conclusion is based upon the analysis of nuclei prepared from a variety of animal tissues by modifications, by us, of non-aqueous isolation procedures introduced by Behrens[5]. A comparison of the composition of nuclei prepared in aqueous and non-aqueous media has shown: (1) that characteristic nuclear enzymes (for example, nucleoside phosphorylase) are often extracted from 'citric acid' or 'sucrose' nuclei; (2) that as much as half the nuclear protein may be extracted and discarded in preparing citric acid nuclei; and (3) that the reported occurrence of nucleotide-specific phosphatases in the nucleus is probably a diffusion artefact resulting from a precipitation or selective adsorption of cytoplasmic enzymes in the nucleus, for example, by formation of complexes with nucleic acid.

In the nuclear isolation procedures applied in this Laboratory, the tissues are rapidly frozen and lyophilized. The dry powder so obtained is suspended in petroleum ether and ground in a ball mill to fragment the cells and liberate the nuclei. Because the nuclei have a characteristic and relatively high density, they can be separated from both lighter and heavier components of the ground tissue suspension by alternate sedimentations and flotations in *cyclo*hexane – carbon tetrachloride mixtures of different specific gravities. Calf thymus nuclei, for example, have specific gravities between 1·38 and 1·41. If ground thymus tissue is suspended in *cyclo*hexane – carbon tetrachloride mixtures of specific gravities less than 1·38, centrifugation sediments the nuclei but floats nuclei with attached cytoplasmic tabs as well as the unground or partly ground cells. At specific gravities greater than 1·41, the nuclei can be floated away from fibre and heavy cytoplasmic debris. In practice, the isolation of pure nuclei by this procedure is tedious and requires many sedimentations and flotations, the details of which will be presented separately[6]. Nuclei so isolated, however, have been shown by many tests to be free of both diffusion artefacts and cytoplasmic contaminants. Thymus nuclei, for example, contain less than 5 per cent of the serum protein concentration measured in the cytoplasm (as determined by precipitin titre with antisera to bovine albumin and globulin); cardiac muscle nuclei contain no myoglobin; kidney nuclei have no uricase or catalase activity, and pancreas nuclei contain only a few per cent of the total amylase and lipase activity of pancreas tissue. Other experiments have shown that: (1) diffusion artefacts are not produced by the freezing and the lyophilization of the tissue, (2) that contaminants are not ground into the nucleus during the milling procedure, and (3) that many enzymes are not destroyed or inactivated during the isolation[7]. In general, the enzymes which can be studied in nuclei so isolated include those which are commonly prepared as acetone powders of the tissues concerned.

In this laboratory nuclei have been prepared from the erythrocytes of the chicken and goose, from the liver of the calf, horse and fasted rat, from calf and fowl kidney, from calf, ox and horse pancreas, and from calf thymus, intestinal mucosa, and heart. No significant cytoplasmic contamination of these preparations could be detected by immunological, chemical or enzymatic tests, or by careful microscopic examination after staining and counter-staining. These diverse nuclei were then examined for their content of nucleic acid and total protein and for their activities in a number of enzyme systems of limited or general distribution.

It was found that the deoxyribonucleic acid content of the isolated nuclei ranged from 12 per cent in horse liver to 26 per cent in calf thymus. From these data and the measured content of 'control' tissue preparations, together with the fact that the deoxyribonucleic acid is localized in the nucleus, it was possible to calculate the nuclear fraction of the different tissues. This fraction varies considerably, from 5 per cent in cardiac muscle to 61 per cent in calf thymus. The total protein content of the different isolated nuclei varies between 74 and 88 per cent, and the ratio of protein to deoxyribonucleic acid, which is a measure of the protein content per nucleus, ranges from 2·8 in calf thymus to 7·3 in horse liver. Extraction of these nuclei with dilute citric acid, however, removes 18–55 per cent of their total protein, the greatest losses occurring in the liver. Therefore the utility of nuclei isolated in citric acid for enzyme studies must be seriously questioned. On the other hand, the protein content of the nuclei which we have isolated is only about a third of that determined by microspectrophotometric methods applied to single nuclei in tissue sections[8]. The exceedingly high protein to deoxyribonucleic acid ratios obtained by the latter technique are probably the result of technical difficulties or of unwarranted assumptions in the calculations, by the Beer–Lambert law, of concentrations in the turbid and refractile nucleus.

The enzymes studied in these diverse nuclei fall into two classes. The first includes those enzymes which are characteristic of certain specialized cells: the arginase of mammalian liver and fowl kidney, uricase and catalase of both liver and kidney, lipase and amylase of the pancreas, and alkaline phosphatase of the intestinal mucosa. Also included in this group are erythrocyte hæmoglobin and myoglobin of the cardiac muscle cell. The second group of enzymes studied shows a wider distribution: alkaline and nucleotide-specific phosphatases (adenosinetriphosphatase, adenosine-3 and 5-phosphatases), esterase, β-glucuronidase, adenosine deaminase, guanase, and nucleoside phosphorylase. In all cases, the enzyme concentrations (in activity units per mgm.) measured in isolated nuclei were compared with the concentrations observed in control tissue preparations, treated with the same solvents for the same duration as the isolated nuclei.

The following distribution was observed for the special components listed in group one. Hæmoglobin was found to be present, and was isolated in crystalline form from fowl and goose erythrocyte nuclei. Myoglobin, however, was entirely absent from heart muscle nuclei. Of the special enzymes considered, only catalase and arginase appeared to be concentrated in some of the nuclei. Arginase activity, for example, occurs in liver nuclei in 80 per cent of the concentration observed in the tissue, and nuclear catalase concentration is about a third of that measured in liver tissue. On the other hand, there was no significant nuclear concentration of amylase, lipase, uricase or alkaline phosphatase. No simple relationship was found between the concentration of a 'special' enzyme in a tissue and its activity in the corresponding nuclei. Arginase activity, for example, which is high in mammalian liver and in fowl kidney, was found in liver, not kidney, nuclei. Similarly, catalase activity was demonstrated only in mammalian liver nuclei, although, in mammals, both liver and kidney are rich sources of this enzyme. Despite the absence of a simple conformity in enzyme pattern between cytoplasm and nucleus, the fact remains that the 'special' components which characterize a tissue may occur in, and thereby characterize, its nuclei. Hæmoglobin, for example, occurs in the erythrocyte nucleus but in no other, and the liver nucleus is readily identified by its content of arginase and catalase.

The enzymes of general distribution (that is, the second group listed above) can be considered in three parts. First there are those enzymes (alkaline phosphatase, the nucleotide-specific phosphatases and β-glucuronidase) which occur in low concentrations, if at all, in the nucleus. The second type is exemplified by esterase, which occurs in all nuclei in widely varying concentrations, depending upon the tissue examined. Finally, there are those enzymes (adenosine deaminase, nucleoside phosphorylase, and guanase) which are present in high proportions in many nuclei. The nuclear concentration of nucleoside phosphorylase, for example, in heart nuclei is more than four times its concentration in the cytoplasm, and comparable activity ratios exist for adenosine deaminase in both heart and liver. When nuclei from different sources are compared, the observed differences in nuclear activity in all these enzyme systems frequently exceed the differences measured between the tissues themselves. This fact, together with the previous observation that specialized cellular components can occur in the nucleus, leads to the conclusion that differentiation is also a nuclear process.

In addition to this picture of the nucleus as a differentiated structure which varies from tissue to tissue, evidence has been obtained which indicates that the nuclear composition varies with the age and physiological state of the cell. The response of nuclei to changes in physiological state was demonstrated by experiments on starvation. In these experiments, the enzymatic activities of normal horse liver nuclei were compared with the corresponding activities of liver nuclei prepared from an animal subjected to a prolonged fast. It was found that the catalase activity of both nucleus and cytoplasm decreased on starvation, whereas β-glucuronidase activity per cell and per nucleus remained essentially constant. All the other enzymes studied—arginase, esterase, alkaline phosphatase, nucleoside phosphorylase and adenosine deaminase—increased in the cytoplasm and decreased markedly in the nucleus.

A further indication of nuclear variability was found by the comparison of fœtal and adult tissues. One result of this comparison was the observation that lipase and amylase, which are so highly active in the cytoplasm of the adult pancreas, are barely detectable in the fœtus; these activities thus appear to be adaptive. The intracellular distribution of adenosine deaminase and nucleoside phosphorylase in fœtal calf pancreas, liver and kidney differs somewhat from their distribution in adult tissues, but in all cases the nuclear concentration of these enzymes is high. The most striking differences in enzyme distribution were found in the comparison of fœtal and adult intestinal epithelia. The cytoplasm of the adult mucosa cell, for example, has forty times the adenosine deaminase activity measured in the fœtus. Increased activities in the adult cytoplasm were observed for all enzymes studied. On the other hand, the relative nuclear activities (nuclear enzyme concentration/cytoplasmic enzyme concentration) are much higher in the fœtal mucosa than in the adult. Only β-glucuronidase activity constitutes an exception to this general decline in relative nuclear activity upon maturation. An additional point of interest is the fact that fœtal mucosa cells are much the same as liver cells or other adult cells with respect to their intracellular distribution of nucleoside phosphorylase and adenosine deaminase. The adult mucosa, on the other hand, does not show the usual high nuclear concentration of these enzymes. This low phosphorylase and deaminase activity of adult mucosa nuclei may be related to the rapid rate of desquamation in the adult epithelium. Tentatively, an analogy may be drawn between the low nuclear enzyme activities of mucosa cells tending to become moribund and the low nuclear activities of liver cells following a prolonged fast.

In summary, the study of enzymes in nuclei isolated from many animal tissues indicates that the nucleus is a differentiated structure the enzymatic composition of which may vary markedly with the age and physiological state of the tissue. Most nuclei do not contain appreciable concentrations of alkaline phosphatase, adenosinetriphosphatase, or other nucleotide-specific phosphatases, but do contain high concentrations of those enzymes (nucleoside phosphorylase, adenosine deaminase and guanase) which are most likely to be involved in nucleoside metabolism. This fact, together with the demonstration that nucleoside phosphorylase catalyses the formation of nicotinamide ribosides[9], and thus part of the synthesis of the pyridine nucleotides, points to a possible role of the nucleus in controlling the formation of di- and tri-phosphopyridine nucleotide coenzymes. Such function would be in accord with the suggestion of Brachet[10] that the nuclear control of oxidative phosphorylation might result from a nuclear mediation of coenzyme synthesis.

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A CENTURY OF FORESTRY*

FORESTRY IN THE UNITED KINGDOM OVER THE LAST CENTURY

By Sir HENRY BERESFORD-PEIRSE

WE must face the fact that the United Kingdom has until recently little in the way of systematic management and development in forestry of which to be proud. Nevertheless, if it is the task of a historian (and I must pretend for a short time to be such a person) to look backwards, so it is his privilege to look forward also; and in forestry there is, I believe, a bright prospect ahead.

If my remarks carry us back more than a century it is because this period marks no clear phase in the story; and if my references are to a large extent to Scotland, this implies no reflexion on England and Wales, but is due to my closer knowledge of Scotland.

Pre-Eighteenth Century

Until the end of the seventeenth century the history of our woodlands was of their destruction, sometimes rapid and widespread, sometimes more gradual. The reason may have been in early days the fear of wild animals, and wolves in particular, which led the people to destroy their natural habitat—the forest; it may have been for fuel that woods were cut, or to make clearings for cultivation. Fires undoubtedly decimated large tracts, and in later years the needs of graziers for sheep walks led to widespread clearances. Iron smelting made large demands for fuel, and this industry has left its heavy mark on the forest area; shipbuilding made inroads into supplies of timber, particularly oak. The causes for the destruction of forest were, in fact, many, but they all had one thing in common: that the destruction was permanent—seldom did young growth spring up to replace the old, climate adding its influence to others to inhibit natural replacement.

While no one could pretend that Britain ever had a forest policy, in the normally accepted sense of this phrase, until as late as 1919, it should not be thought that our rulers and Governments were insensible to the serious results of the continuous reduction of our forest area. From the fourteenth century onwards, there were a series of Acts aimed at reversing this trend; but they were generally purely restrictive, prohibiting fellings, and only occasionally insisting on planting when felling was done. These enactments were largely ineffective, and at no stage was there any really constructive measure taken to build up a properly managed forest area.

Eighteenth Century

This process of reduction continued long after the seventeenth century. Demands for grazing increased as border graziers extended their activities ever farther north. Scotland, in particular, was poor, and timber was one of its few assets, so that it is not surprising to find sales of timber being made to commercial concerns from the south, like the York Timber Co., which devastated Strathspey from 1728 onwards (losing, incidentally, a lot of money in the process). But at the very end of the seventeenth and beginning of the eighteenth centuries there are first signs of forestry proper being undertaken by a few big landowners. But these were isolated cases, and the disturbances and forfeitures of the times of the '15 and '45 risings were not conducive to forestry development.

While the scale on which forestry was carried on at this time was negligible, the really significant development was the introduction of the first exotic conifers by a few enterprising arboriculturists. It must be remembered that, while Great Britain had a reasonably good indigenous stock of broad-leaved species capable of producing high-quality timber, she was very poorly supplied with conifer species, having only one of commercial importance—Scots pine (*Pinus silvestris*). This scurvy treatment by Nature or chance—call it what you will—seems particularly unkind, as we know that in prehistoric times other species grew here (for example, *Tsuga heterophylla*, the fossilized cones of which have been found); and we are blessed by a climate most suitable for conifers, and a geology more varied than perhaps in any other area of similar extent in the world. So we might have expected to find here a wide range of coniferous species, instead of one only. It was an event, then, of outstanding importance when other species were introduced and distributed about the country.

The importation came first, as was to be expected, from Europe, of European larch (*Larix decidua*), silver fir (*Abies alba*) and Norway spruce (*Picea abies*), and the trees grew with great vigour. But it was not until the more peaceful times of the second half of the eighteenth century that the new species were planted on any scale, and then it was mainly European larch and Norway spruce. By far the greatest enterprise was shown by John, Duke of Atholl, who afforested in Perthshire in the last quarter of the eighteenth and first quarter of the nineteenth centuries no less than 8,000–9,000 acres, mainly with larch. Writing of this great enterprise, Sir John Stirling Maxwell, who has himself been no less daring in his forestry, says: "This was the first large-scale experiment in any country with an exotic conifer. No landowner ever made a sounder investment." It is of some interest that the Atholl estate has to-day a very similar acreage of forest, and it is to be hoped that its investment in forestry now will be no less sound than that of the founder of its forests. His fine example of planting was followed by many other landlords throughout the United Kingdom, and the foundation was laid of the great woodland estates, and lesser ones as well, which built up a stock of timber mainly of larch, Norway spruce and Scots pine on which the country was glad to depend for the bulk of her timber supplies in the two World Wars of the first half of this century.

One other tree is worthy of mention, though its importance is limited, namely, the Corsican pine (*Pinus nigra* var. *calabrica*). Introduced in the mid-eighteenth century, its rapid growth under dry sandy conditions has led to its successful use in East Anglia

* Substance of the chairman's address (Sir Henry Beresford-Peirse) and a paper (Prof. E. P. Stebbing) read to Section K* (Forestry) on August 9 at the British Association meeting at Edinburgh.

and, more surprisingly, on the Culbin Sands in Morayshire; for surely there can be few cases such as this of a tree successfully transplanted in its own hemisphere some 1,200 miles north of its natural habitat.

Nineteenth Century

The promise of real progress was, however, not fulfilled as the nineteenth century wore on. For a time, Governments were concerned about supplies of oak for shipbuilding and gave attention to the management of Crown forests and the planting of oak. With the coming of the iron ship, however, even this interest in forestry faded. Industry, centred in large towns, and not the best and full use of land, was what mainly interested this country; capital was increasingly drawn towards manufacturing and away from the land. Industrial development was accompanied, of course, by an ever-growing demand for timber, a demand more and more for softwoods rather than hardwoods. This trend was important because of the effect it had on forest policy when at last it came to be formulated in the following century. But Europe and America were only too ready to send us what we wanted, and we were prepared to import from the pick of the world's markets. There seemed no reason to bother about home supplies; or so thought the Government, for it was common to find in Government contracts for construction work a clause that no home-grown timber was to be used. Small wonder that forestry in Britain had to struggle to keep alive, and that planting barely kept pace with fellings.

Nevertheless, the process of introducing exotics went on steadily throughout the nineteenth century—a process that was its main contribution to forestry development. It was the great era of plant collectors, and in the first half of the century no fewer than eight hundred species of exotic trees and shrubs were brought in. Those of importance in commercial forestry came mainly from North America—the most useful were perhaps Douglas fir (*Pseudotsuga taxifolia*) and sitka spruce (*Picea sitchensis*), brought in by David Douglas and his followers. But there were numbers of other species, notably the grand and noble firs (*Abies grandis*, *A. nobilis*), western hemlock (*Tsuga heterophylla*) and western cedar (*Thuya plicata*), all of which flourish in Britain, and of which too little use has even yet been made. The redwoods were also introduced, but have been almost wholly neglected as forest trees. These exotic conifers, and many more, can be seen throughout the length and breadth of these islands in gardens, parks and arboretums. Rarely were they planted in forest conditions on any great scale; but the work of trying out new species that was done on certain estates was of inestimable value when at long last a real forest policy was initiated in the twentieth century.

North America was the main, but not the only, source of exotics. Among species introduced from Asia it is the Japanese larch (*Larix leptolepis*) which must be given pride of place. Brought in by J. H. Veitch, it was again a Duke of Atholl (the seventh) who first planted a few trees at Dunkeld in 1883. Whether by design or chance, he chose a site near some magnificent European larch trees and within a short distance of one of the original European larch planted by his forbear nearly 150 years earlier. The remarkable hybrid that resulted has given Britain a tree of outstanding importance. It is, however, symptomatic of the way we have treated forestry in the past that we left it to Scandinavian foresters to carry out research on this hybrid and take serious steps to provide a supply of first-cross hybrid planting stock. We were content to collect such seed as we could off the original parents, and also from the hybrid itself, without much idea of what we were getting from this second cross. It is good, however, to record that nearly fifty years after hybrid larch seed first germinated (1904), we are taking steps to ensure future supplies of seed.

This introduction of exotics, while carried out mainly by botanists, must none the less have its place in any history of British forestry, for it was the foundation on which our twentieth-century expansion has been built. The need for a real forest policy and an extension of planting was increasingly felt in the second half of the nineteenth century, and had its expression in the founding in 1854 of the Scottish Arboricultural Society, now the Royal Scottish Forestry Society. An English Society followed in 1881—the Royal English Arboricultural Society. These Societies grew steadily in importance and influence, and began to press on the Government their views on the urgent need for a progressive forest policy. Towards the end of the century the Scottish Society was urging the President of the Board of Agriculture to take some active interest, and in 1891 forestry was first given recognition by a university by the appointment at Edinburgh of a lecturer in forestry; in the same year Durham appointed a professor of agriculture and forestry. This followed a Select Committee on Forestry which sat during 1885–87. But academic training was not enough, and the Society urged the Government to create what was called a "Model State Forest", where practical work and research could be undertaken. Before the close of the century, the Society was putting forward the proposition that the 900,000 acres of woodland in Scotland could with great advantage to the country be increased to four or five times its area, while the Royal Commission on Coast Erosion and Forestry made alternative proposals in 1909 for the afforestation of nine million or six million acres in the United Kingdom. These were ambitious ideas; but nothing much happened and only a few thousand pounds were spent by the State on planting before 1914. In the same year (1909), the Office of Woods acquired land for the first State forest in Scotland, an area on Loch Awe in Argyllshire—Inverliever—to add to its forest property south of the Border, and it is interesting to record that this was put in charge of a technical officer—Mr. R. L. Robinson, now Lord Robinson, chairman of the Forestry Commission.

Twentieth Century

At this time, 1910 and thereabouts, there was a group of Scottish landowners, headed by Lord Lovat, who firmly believed that a cure for many of the economic and social difficulties of Scotland lay in large afforestation schemes. For many years there had been a steady drift of population away from the Highlands and, indeed, from the Lowlands too, and the same was true of the hill country of England and Wales. The reason was that sheep grazing, which was the main form of farming, required little labour, gave poor reward and offered little opportunity for enterprise; and the call of the Colonies and industry was strong. Forestry seemed to offer just the type

of expanding employment and opportunity which would induce young men to stay in, or return to, even the most remote parts of the country. In order to demonstrate the practicability of his ideas, Lord Lovat and his brother-in-law, General Stirling of Keir, carried out a sample survey in Glen Moor in Inverness-shire. The result was published in 1911, and made an impressive case for a large extension of forestry. In the same year, the Government told the Forestry Society that it contemplated setting up a Forestry Department.

World events were now, however, moving fast towards war, and when it came the almost disastrous difficulties of importing that most bulky of raw materials, timber, swept away any remaining doubts the Government still had about the parlous state of home supplies and the need for State action. While the War was still going on, the Acland Committee was set up "to consider and report on the best means of conserving and developing the forest resources of the United Kingdom". It reported in 1917, and its recommendations were accepted by the Government towards the end of 1918. This event is a landmark in our forest history because it was, in effect, the birth of a national forest policy. Consequently, it is worth recalling the situation as the Acland Committee saw it. The woodland area of the United Kingdom was estimated at three million acres; but the increment was thought to be only about one-third of what it should have been under proper management; and this poor increment was only 8 per cent of our consumption of timber. It is not necessary to go into any greater detail to show how precarious was the supply of a vital raw material, and how urgent and necessary it was for the Government to take action. To meet the situation, the Acland Committee proposed that, in order to make the United Kingdom self-sufficient in timber for three years in any future emergency, there should be afforested 1,770,000 acres. In addition, the existing woodland area of three million acres was to be maintained and its production improved. In all, then, there would be in the United Kingdom a forest area of about 4¾ million acres. The afforestation of new land was to be the task mainly of the State; private planting was to be helped and encouraged by grants. It was recommended that a Forest Authority should be set up which would have the care of all forestry matters, would administer the grants for private planting and would carry out directly the afforestation programme. These, very briefly, were the recommendations of the Acland Committee to which statutory effect was given by the passing of the first Forestry Act in 1919. In November of that year the Forestry Commission came into being with Lord Lovat as chairman.

In its early infancy, State forestry almost suffered extinction, as the Geddes Committee on National Expenditure recommended in 1922 that the Commission should be abolished and its work should be stopped. However, largely by the personal efforts of Lord Lovat, and because a good start had been made in the acquisition of land and in planting, the Government decided that State forestry should continue. The recommendation for abolishing the Commission was made on financial grounds, and changes in policy of the kind accompanied by a fluctuating programme due to financial consideration, with all the confusion that this entailed, are characteristic of the progress of forestry in the inter-war period. I do not wish to go into any detail as to how the programme proposed by the Acland Committee was carried out. Suffice it to say that at the end of the first twenty-year period, that is, at the outbreak of the Second World War, the Forestry Commission had acquired some 650,000 acres of plantable land and had actually planted nearly 370,000 acres. In spite of the fluctuation in the supply of finance, this achievement represented 88 per cent of the acquisition programme and 75 per cent of the planting programme that the Acland Committee had recommended. Two other activities were begun which did not form part of the Acland Committee's Report. The first was the formation of forest workers' holdings, which began in 1924. Up to 1939, nearly 1,500 had been established. The second development was that of national forest parks. The first two were opened before the War—one the Argyll National Forest Park in Scotland and the other, the Forest of Dean. Several others have since been opened. The idea was to provide recreational facilities for the public within the forest area itself and also outside on bare hill-land which is often acquired by the Commission together with the plantable area. Some of the most magnificent country in the United Kingdom has in this way been made available to the public.

The other part of the story of forestry in the inter-war period concerns private estates. The Acland Committee merely recommended that the Forestry Commission should be allowed "to make limited grants for every acre replanted or newly afforested, . . . such plantations to be made in accordance with approved plans and conditions". In the event, the amount of the grant was fixed at £4 for hardwoods and £2 for conifers. Such an amount may seem small by present-day standards; but in 1919 they represented a not inconsiderable proportion of planting costs. Private estates certainly took advantage of these grants, and in the twenty-year period 125,000 acres were planted with their aid. But little was done about "approved plans and conditions". Some planting was undoubtedly done without grants and of that there is no record, but it is not thought that this planting extended to any very great acreage. Allowing, then, for some failures and for the non-grant plantings, it would not be far from the mark to say that about 130,000 acres were privately planted between the Wars. Taken by itself, this is a not inconsiderable effort; but we must set it against the area of 450,000 acres which, it is estimated, was felled during and immediately after the First World War. Furthermore, clear felling, unrestricted by anything but economic circumstances, was going on all the way through the inter-war period. When we add State and private planting together we find that something like half a million acres were put under trees by 1939; but that amount had not even made good the ravages of wartime fellings and the subsequent cutting that took place. That was the situation that faced the country at the outbreak of the Second World War, and by that time very few of the new plantations were of a sufficient age to produce utilizable timber.

In considering the Acland Committee's Report, one must be struck by the far-seeing, yet realistic, recommendations that it made. If there is one criticism that can be levelled at the Report it would be that, in planning for the build-up of a forest reserve, it made provision only for planting, and no suggestion whatever was put forward for any restriction on the felling of existing woods and plantations. Taking a short-term view, restriction on fellings would

have been a quicker method of building up a reserve of timber than any planting that could have been carried out.

The Second World War is an almost exact repetition so far as forestry is concerned of the First. Again there came the difficulty of importing a bulky raw material; again our much depleted home woodlands had to be still further stripped to meet our needs. These two facts made it clear that even more drastic measures than those recommended by the Acland Committee would be needed to put forestry on a sound footing when peace should come. Early in the War, the duty of providing timber from home sources had been taken out of the hands of the Forestry Commission and passed to the Ministry of Supply. The Commission was therefore left comparatively free to give thought to planning for post-war forestry, and in 1943 it produced a White Paper entitled "Post-War Forest Policy", which has formed the basis of forest policy since the War. Early in 1944, a second White Paper was published dealing particularly with private woodlands. It may be well to give the main recommendation of these two White Papers. In short, it was to build up in the United Kingdom by the end of this century a forest area of five million acres. This was to be made up of two million acres from existing woodlands and three million acres by the afforestation of bare land. This afforestation would be carried out in the main by the State; replanting and the tending of existing woodlands would be done privately; but wherever it was found impossible for the present owners to carry out replanting, it was proposed that the State should take over these woodlands and do the work itself. It was estimated that there were some three million acres of existing woodlands, but it was thought that perhaps only two million acres would be suitable for systematic management. An important part of the first White Paper and the whole of the second White Paper dealt with what has now come to be known as the Dedication Scheme. It was recognized that, if forestry development was to be successful, private estates must play a full part and that there must be some carefully thought-out plan providing for two main essentials; first, that the private woodlands be worked systematically under sound sylvicultural management, and secondly, if this were done, that the State should provide substantial financial assistance to the owners. The Dedication Scheme provides that an owner who goes in for it must sign a legal document which is binding on the land for all time. In it, the owner undertakes to use the land so that timber production is the main object; he agrees to work his woodlands according to a plan approved by the Forestry Commission; and he undertakes to have skilled supervision. For its part, the Forestry Commission promises to pay certain grants for planting and maintenance—at present, the planting grant stands at £12 per acre (since raised to £14 per acre); loans are also available, and it is part of the Scheme that the State Forest Service will provide advice to any woodland owner who may require it. Before it was launched, the Scheme was discussed in some detail with representatives of private owners. The general principles were agreed; but it is not surprising that in a scheme so far-reaching and so novel for Britain that some of the details of it should have been received with a good deal of suspicion. Considerable alterations have recently been made to some of the conditions of the legal agreement, and as a result, the details as well as the general principles have now been accepted by private woodland owners. One further aspect of the Post-War Forest Policy White Paper is of importance. It was then clearly recognized that, in the interests of the forest industry, there must be a sound and efficient home timber trade if growers' produce was to be properly exploited, converted and manufactured.

I have devoted some time to discussing the provisions for private forestry because the introduction of the Dedication Scheme is another landmark in the history of forestry in Great Britain. For the first time, statutory recognition was given to private forestry; the State assumed some measure of control over it, and at the same time obligations for financial and other assistance. As I have said, too, the need for a sound home timber trade was recognized. A further Forestry Act is now becoming law (the 1951 Forestry Act came into force on October 1, 1951), and the main objects are to transfer to the Forestry Commission the war-time powers to restrict fellings and so help to build up a reserve of standing timber. There will also be power to give direction for fellings, so that, for example, over-mature timber could be made available for consumption, and powers to attach conditions to felling licences, for example, to ensure replanting. These powers will apply only to non-dedicated woods. With this Act the requirements of a proper forest policy will be reasonably complete, each of the three parties concerned—private growers, home timber trade and State—having definite main spheres of activity, but all closely linked together.

The fifth planting season since the post-war programme was introduced in 1946 has now been completed, and it may be of interest to take stock of progress. In brief, the State has achieved about 72 per cent of the planting programme laid down, having planted in these five seasons rather more than 210,000 acres, while private forestry has dealt with nearly 26,000 acres, about 75 per cent of what the White Paper anticipated. Although these figures are appreciably less than the programme, they are very substantial areas and represent no mean achievement, taking account of all the difficulties of these post-war years. The main reasons for falling below the programme were shortage of labour, shortage of plants, and, in the case of the Forestry Commission, shortage of land, the latter affecting particularly England. Though the task that Britain has set itself is a very large one, there is no reason why it should not be achieved, for there are a number of conditions entirely suitable for large-scale forestry. We have, for example, a great extent of rough hill grazings, some sixteen million acres in all (including deer forests and other high land), and it should be possible to abstract the comparatively small area that we need to make up the forest area at which we are aiming without unduly interfering with agricultural production. Again, much of the climate and soil of Britain is highly suitable for tree growth. Finally, thanks to those far-seeing and enterprising men who introduced so many exotic conifers over the past two hundred years or so, we have a wide range of species to choose from, many of which have been tried out already.

The very size and momentum of the task makes it important to ensure that technique keeps pace with the programme with which it has to deal and is capable of using the many species which are available. An important objective is to be able to establish

plantations on the less-fertile hill land so that good grazing need not be disturbed. For pioneer work in this field, the name of Sir John Stirling Maxwell will always be remembered. He introduced into Britain the Belgian system of turf planting at his Corrour property on the Moor of Rannoch in Inverness-shire, and over a number of years from 1925 he developed methods of dealing with high-altitude peat-covered land which has pointed the way for the Forestry Commission to follow in its more extensive operations. All the Corrour plantations lie above the 1,250 ft. contour, a height below which most foresters would have finished their planting, and this is a measure of the enterprise that was shown. At Corrour, draining and cutting and spreading of turfs was done by hand, and the cost was heavy. The obvious method of cheapening this kind of work was to do it mechanically, and various ploughs were tried by the Forestry Commission. The difficulty, however, of finding a suitable machine to pull the plough in soft peat was not solved until the caterpillar tractor reached Britain shortly before the Second World War. Subsequent development has been rapid; until now, ploughing before planting, not only on peat-covered land, has become normal practice wherever a plough and tractor can work. I would not imply that Sir John Stirling Maxwell is the only private forester who has contributed to development of technique; far from it. There are, for example, a number of estates where the treatment of hardwood areas, particularly in the south of England, is enlightened and enterprising, and far in advance of normal practice. But Sir John Stirling Maxwell's work was concerned with afforestation of difficult non-woodland country and therefore had an important influence on the State's afforestation programme. Two exotic species in particular have proved of special value in the afforestation of peat-covered land—sitka spruce and lodgepole or shore pine (*Pinus contorta*)—and the use of these exotics together with ploughing has undoubtedly greatly extended the area on which planting can be carried out with a reasonable hope of success. In less difficult conditions, too, ploughing helps to get over an initial check and may advance the beginning of proper growth by five or even ten years, which is important when the aim is to build up timber reserves as quickly as possible.

Of all forestry operations, nursery work has perhaps been slower in development than any other. Until the last five or six years, old methods had been generally accepted, although there was clearly great scope for reducing cost of plants and improving stock. Let me give one example only. There are in 1 lb. of sitka spruce seed upwards of 200,000 seeds; yet the usual outturn of plants suitable for putting on the hill used to be around 15,000. There would seem to be room for improvement here. It is good to be able to record that in the last few years considerable steps forward have been made. Largely due to the most valuable work done by Dr. M. C. Rayner in the use of composts, it is now common practice to sow seeds in nurseries prepared on woodland or heathland sites and to improve the output of usable plants per pound of seed by three or four times, and to take a year or two less to do this. Mechanization in the nursery has also gone ahead and there are now machines which will do the whole operation of lining out, except filling the boards and setting them in position. It is probable that before long sowing and lifting will also be done mainly mechanically. We are only at the beginning of the use of machines on the hill and in the nursery; but these developments are particularly welcome just now when labour is in such short supply and is so expensive.

Finally, I must refer to the most recent and possibly most important line of progress—tree breeding. This is a branch of the science of forestry which has been neglected in Britain, although a few voices have been raised from time to time to urge that attention be paid to it. Broadly speaking, we have been content to plant the various species on sites that we judged were suitable, largely ignoring the wide variation that exists within each species; we made little serious attempt to collect seed, or breed by other means, only from first-class parent trees. Following the inspiring lead in this field given by Scandinavian foresters, Britain has at last set out, very gingerly, on the selection of élite parent trees, research into vegetative reproduction of conifer and hardwood species, and the establishment of seed orchards to give us supplies of seed of known origin and characteristics. The importance of genetics and its application in agriculture has long been recognized. It is not too much to hope that similar advances may also be made in forestry, resulting in better stands of timber both as regards quality, quantity and cost. I have already referred to the hybrid larch; it is thought, and I believe rightly, that this cross has an important place in British forestry. Only lack of seed limits its use, and if there can be established seed orchards to give all the first-cross seed needed, something worth while will have been achieved. To take a very different case—oak; it is the present teaching that oak should be grown pure, and the number of trees put in per acre should be 4,000–5,000, largely to give the necessary scope for selection of the 40–50 final trees required. This is an expensive method. If we can be assured of a steady supply of acorns or planting stock of unquestionably first quality and vigour, far fewer oak plants would be needed and the balance of ground could be used for growing quicker-maturing species giving an intermediate yield. I need not pursue the application of genetics further, though I believe tree breeding offers for the first time the possibility of making really full use of the best of our own indigenous hardwoods, our one indigenous conifer, exotic and hybrid poplars and the great choice we have of exotic conifers. This work of tree breeding may make the twentieth century as important to Britain's forestry as the introduction of conifers made the eighteenth and nineteenth centuries.

If I have not touched on the exploitation and conversion of forest products, it is not because of any disregard for their important place in forestry in its broadest sense, or because there has been no activity or development in this field. It is rather that I have confined myself to the growing of forests rather than to the handling and use of timber. But I hope that what I have inadequately and sketchily told of British forestry will seem to justify what I began by saying that, while the past centuries have been remarkable mainly for their lack of policy and achievement, the last two or three decades have seen the establishment of a comprehensive forest policy and notable developments in technique. These give promise of magnificent woods in the future which will make profitable the large-scale investment in forestry both by the State and private growers, which is the programme on which Great Britain has embarked.

(*To be continued*)

NEWS and VIEWS

Geological Society of London : Medals and Awards

THE Council of the Geological Society has made the following awards :

Wollaston Medal : Prof. H. H. Read, for his outstanding contributions to the interpretation of metamorphic rocks and to the problem of the origin of granites, and for his services as president of the International Geological Congress, held in London in 1948.

Murchison Medal : Prof. W. J. Pugh, director of the Geological Survey of Great Britain, for his researches on the stratigraphy and tectonics of the Lower Palæozoic rocks of Wales.

Lyell Medal : Dr. A. K. Wells, for his studies of the igneous rocks of Merioneth and Jersey and for his contributions to the teaching of petrology and stratigraphy.

Wollaston Fund : Mr. C. T. A. Gaster, a distinguished amateur who has done excellent work on the palæontology and zoning of the Sussex Chalk.

Murchison Fund : Mr. N. L. Falcon, for his geological researches in many parts of the world and in particular for his work on oil exploration in the United Kingdom and on gravitational and magnetic exploration.

Lyell Fund : A moiety to Dr. R. M. C. Eagar, for his work on variation in carboniferous non-marine lamellibranchs, especially of the Lower Coal Measures, and for his stratigraphical studies in Yorkshire and Lancashire ; another moiety to Dr. R. B. McConnell for his work as a structural geologist in the Lake District, Switzerland, and rift valleys of Africa.

Zoological Society of London : Dr. S. A. Neave, C.M.G., O.B.E.

IT has recently been announced that Dr. Sheffield A. Neave is retiring from the honorary secretaryship of the Zoological Society of London in April. After a distinguished career at Oxford, both in the academic and athletic fields, Dr. Neave devoted some ten years to entomological research in tropical Africa. During this period he gained a wide knowledge of the entomological problems of the continent and of its wild life. In 1914 he returned to Britain to become the first assistant director of the Imperial Bureau of Entomology (now the Commonwealth Institute of Entomology), which had been established the previous year. He was appointed director of the Institute in 1942 and retired in 1946. His outstanding service was the development of the Institute's Publications Office, including the production of the *Review of Applied Entomology*, a journal that is regarded as indispensable by economic entomologists. During 1939–40 he produced, in four volumes, his "Nomenclator Zoologicus", a standard reference work of the greatest importance to every systematic worker in the field of zoology. A fifth volume was published in 1950. For fifteen years (1919–33) Dr. Neave served the Royal Entomological Society of London as secretary, and for the last two years he was president of the Society. He became a Fellow of the Zoological Society of London in 1909, and after serving for several years on the Council was elected honorary secretary in 1942. His outstanding administrative ability and wise counsel coupled with his very wide knowledge of zoology, have had a most valuable and stimulating influence in the entomological field and in the wider field of zoology. His contributions in the bibliographical sphere represent a major contribution to the advancement of entomological and zoological knowledge.

Viscount Chaplin

VISCOUNT CHAPLIN has been appointed honorary secretary of the Society in succession to Dr. Neave. After the resignation of Dr. Julian Huxley, the Council altered the nature of the secretaryship and made it an honorary office similar to those of the president and treasurer, and Dr. Neave has occupied this position since 1942. Lord Chaplin possesses outstanding qualifications as his successor. He has served on the Council of the Society during 1934–38 and during the past year, and for many years has been one of the most constant benefactors to the menagerie at Regent's Park, his donations including innumerable birds, many new to the collection, and also mammals, reptiles and amphibians. He has had practical experience of keeping various species in captivity, and in a recent publication described the rearing of a pair of bee-eaters rescued as nestlings from a snake in the Camargue. He has contributed various articles on natural history to *Zoo Life* and other publications and at one time was editor of the *Avicultural Magazine*. He has a special interest in sun-birds, humming-birds and tree-frogs, and has recently brought forward evidence in support of the view that European tree-frogs comprise two distinct species, *Hyla meridionalis* and *Hyla arborea*, the latter with two varieties, *H. a. arborea* and *H. a. savignyi*. These he distinguished not only by their markings but also by their song. He accompanied Lord Moyne as naturalist during the voyage of the *Rosaura* to New Guinea in 1936 and wrote the natural history appendix—"Walk-about"—in the account of that cruise. He is a gifted artist, and an exhibition of his paintings of humming-birds was held at Londonderry House in 1933. Apart from his general interest in natural history, Lord Chaplin is an accomplished musician and composer and at one time planned to make this his career. During the War he served as a flying officer in the R.A.F.V.R.

Royal Photographic Society : Progress Medal

THE Council of the Royal Photographic Society has awarded the Society's Progress Medal, its highest award, to Mr. J. Dudley Johnston, in recognition of the invaluable services he has rendered to the Society and to the advancement of photography, particularly in the pictorial field. The award of this Medal is considered each year, but is only made where the Council is satisfied that there is a candidate really deserving of it. The Medal has been awarded forty times, twenty-one recipients being of British nationality and nineteen of other nationalities. Mr. Johnston was made O.B.E. in 1947 for his services as curator and honorary secretary of the Royal Photographic Society. In 1948 he was awarded the Progress Medal of the Photographic Society of America, for "inspiring leadership".

Louis Brennan (1852–1932)

MEN of different nationalities have played a part in the development of the torpedo, which is believed to have been invented around 1805 by the American engineer, Robert Fulton. The first successful automobile torpedo was designed in 1866 by the Scottish engineer, Robert Whitehead, whose mechanical skill revolutionized the original conception of Captain Luppius, of the Austrian Navy. Louis Brennan,

who was born a century ago, on January 28, 1852, at Castlebar, Co. Mayo, was the inventor of the Brennan torpedo. At the age of nine he emigrated to Australia. While working as a watchmaker in Melbourne he conceived the idea of a dirigible torpedo for coast defence, which could be fired and controlled from a fixed position on the shore. His machine was fish-shaped and had two screws revolving in opposite directions; drums, mounted on each propeller shaft, were wound with wires of fine steel, the ends of which were connected with a high-speed engine on the coast. The torpedo was steered by varying the rate at which the wires were unwound, and thus the relative speed of rotation of the screws. In 1880 the Admiralty appointed a committee of naval officers serving on the Australian station to report on this invention. On their recommendation, Brennan returned to Britain and was attached by the War Office to the Royal Engineers at Chatham. Seven years later he was appointed superintendent of a government torpedo factory at Gillingham, serving as its consulting engineer during 1896–1907. At Gillingham he began work on a monorail locomotive with gyroscopic stabilizers, which he demonstrated at a conversazione of the Royal Society in 1907 and which had a public trial run two years later; but it did not come into practical use. During the First World War he served with the Ministry of Munitions, and during 1919–26 with the Air Ministry at the Royal Aircraft Establishment, Farnborough, experimenting with a helicopter. He was made a C.B. in 1892, and in 1922 became a foundation member of the National Academy of Ireland. He died on January 17, 1932.

Awards for Radar Inventions

The Ministry of Supply and the Admiralty have considered many claims for awards and compensation in relation to inventions which have been used by the Armed Forces of the Crown in radar equipment. A large number of these claims have been dealt with by the Government department concerned without reference to the Royal Commission on Awards to Inventors. But the claims of twenty-four claimants, after receiving preliminary consideration by the department concerned, were referred to the Commission by the Treasury. The first public hearing before the Commission took place on April 12, and each of the twenty-five claimants was, in accordance with the Commission's procedure, permitted to address the Commission and to call such evidence in support of his claim as he desired. Evidence was called by and on behalf of the Crown. The Commission was advised that the Ministry of Supply and the Admiralty had already paid independently of the Commission a sum of about £200,000 by way of award and compensation to claimants other than those heard by the Commission in respect of the development of radar devices. After full consideration of the evidence, the Commission has recommended to the Treasury that a further sum be paid in regard to the use by, and on behalf of, the Crown of radar inventions as follows: Sir Robert Watson-Watt, in respect of his initiation of radar and his contribution to the development of radar installations, £50,000; Dr. E. G. Bowen and Mr. A. F. Wilkins, £12,000 each; Mr. L. H. Bainbridge-Bell, Mr. H. Larnder, Mr. G. A. Roberts, Dr. D. Taylor and Dr. A. G. Touch, £2,400 each; Mr. W. A. S. Butement, Mr. R. Hanbury Brown and Mr. P. E. Pollard, £1,200 each; Mr. R. H. A. Carter, Mr. H. Dewhurst, Dr. J. H. Mitchell, Mr. S. Jefferson and Mr. B. Newsam, £750 each; Wing-Cdr. E. J. Dickie and Dr. B. J. O'Kane, jointly, £500; Mr. P. A. Marchant, £250; Mr. P. A. Marchant and Mr. D. A. Weir, jointly, £250; Mr. R. V. Whelpton, £250. The Commission did not recommend any award in respect of the joint claim by Sir Robert Watson-Watt, Mrs. G. Fleming Herd and Mr. L. H. Bainbridge-Bell, or to Mr. D. N. Sharma and Mr. L. L. K. Honeyball. The total sum recommended by the Commission in respect of these claims is £94,600. The awards recommended are *ex gratia* and are not likely to be subject to tax.

Prehistoric Cave Paintings in South Africa

Miss J. R. Harding has continued her archæological explorations on the farm Trekpod in the district of Bethlehem, Orange Free State, and some more poorly drawn paintings, with the bodies of the animals filled in with dots, have been noticed. These investigations are recorded in the June 1951 issue of the *South African Archæological Bulletin* (see also *Nature*, August 18, 1951, p. 275). The results of Miss Harding's work in Bethlehem and previously in Saulspoort, Transvaal, can best be given briefly in her own words: "The people making the Smithfield C stone implements were contemporary with the early Bantu settlers . . . of very recent date; and present-day Bushmen are the degenerate remnants of the Smithfield C people" . . ., or, again, she suggests "the Bushmen themselves were the makers of the Smithfield C implements. In the absence of any earlier remains in this shelter, I believe that the paintings on its walls must also be assigned to the Smithfield C period". The paintings at Trekpod and at Saulspoort are different in style from the well-known so-called Bushman art of the Union of South Africa and not necessarily of the same age. At the same time, one is more and more inclined to doubt the great antiquity of the main bulk of the latter. In the Union there are vestiges of earlier paintings which may well date to a remoter period, and these can be equated with the later phases of the art in Southern Rhodesia; the earlier phase in this area may be very old indeed. There are reasons, however, for dating much of the rock-shelter art in the Union to a more recent period, and Miss Harding's work supports to some extent this contention.

International Symposium on Problems of Desert Research

The Research Council of Israel, in co-operation with Unesco, is planning a symposium on desert research in Jerusalem during May. This will aim at giving an integrated picture of the present state of desert research. It will last about a week, four days of which will be devoted to meetings, and these will be followed by excursions into the Negev, the arid zone in the south of Israel, and visits to other places of interest in the country. Five sections are envisaged for the symposium: (1) climate; (2) soil; (3) water; (4) energy; (5) biology. Among those who have agreed to present papers are: Prof. J. B. Leighley (University of California), Dr. W. S. S. Ladell (Hot Climate Physiological Research Unit, Oshodi, Nigeria), Prof. W. C. Lowdermilk (U.S. Department of Agriculture), Brigadier R. A. Bagnold (Great Britain), Mr. A. N. Khosla (Central Water and Power Commission, India), P. Danel (Laboratoire Dauphinois d'Hydraulique, France), Prof. Th. Monod (Institut Français d'Afrique Noire, Dakar) and Prof. F. W. Went (California Institute of Technology). Further

particulars and application forms can be obtained from the Research Council of Israel, P.O.B. 607, Jerusalem.

Institute of Metals : Officers

THE following have been elected officers of the Institute of Metals for the year 1952–53, and will take office on March 25. *President :* Dr. C. J. Smithells, director of research, British Aluminium Company, Ltd., Gerrards Cross, Bucks; *Vice-Presidents :* Mr. G. L. Bailey, director, British Non-Ferrous Metals Research Association, London; Dr. S. F. Dorey, chief engineer surveyor, Lloyd's Register of Shipping, London; *Honorary Treasurer :* Mr. E. H. Jones, director and general manager (Bristol), Capper Pass and Son, Ltd., Bristol.

The Night Sky in February

FULL moon occurs on Feb. 11d. 00h. 28m., U.T., and new moon on Feb. 25d. 09h. 16m. The following conjunctions with the moon take place : Feb. 15d. 14h., Saturn 7° N.; Feb. 17d. 15h., Mars 7° N.; Feb. 23d. 03h., Mercury 3° N.; Feb. 28d. 08h., Jupiter 5° S. Mercury, in superior conjunction on February 22, is too close to the sun during the month for favourable observation. Venus, a morning star, rises at 5h. 45m., 6h. and 5h. 50m. on February 1, 15 and 29, respectively. The stellar magnitude varies between −3·5 and −3·4, and the visible portion of the illuminated disk between 0·80 and 0·87. Mars rises at 0h. 30m., 0h. 10m. and 23h. 40m. on February 1, 15 and 29, respectively; about the middle of the month and for some time later, the planet lies a little south of α Libræ. Jupiter is an evening star, setting at 22h. 10m., 21h. 35m. and 20h. 55m. at the beginning, middle and end of the month, respectively. Saturn, an evening star, rises at 22h. 35m. on February 1 and at 20h. 40m. on February 29, and can be seen a little north of θ Virginis throughout the month. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich : Feb. 3d. 23h. 12·6m., 7 Taur. *m.* (*D*); Feb. 27d. 18h. 28·2m., 51 Pisc. (*D*). *D* refers to disappearance. A partial eclipse of the moon takes place during February 10–11, visible at Greenwich. The magnitude of the eclipse is 0·088, taking the moon's diameter as 1. The circumstances of the eclipse are as follows :

Moon enters penumbra	Feb. 10d.	22h.	06·2m.
Moon enters umbra	11	00	03·3
Middle of eclipse	11	00	39·3
Moon leaves umbra	11	01	15·3
Moon leaves penumbra	11	03	12·4

A total eclipse of the sun takes place on February 25 and is visible as a partial eclipse at Greenwich, where its magnitude is 0·11. At Greenwich the eclipse begins at Feb. 25d. 08h. 42m. and ends at 9h. 47m., the greatest phase being at 9h. 14m. The line of totality commences close to the equator and about midway between the American and African coasts, passing over Libreville, Bangui, Khartoum, Basra and Khiva, and ending at Semipalatinsk at 11h. 44·2m.

Announcements

BY an order of the Committee of Privy Council for Medical Research, the Earl of Limerick has been appointed a member of the Medical Research Council; the Council has appointed him to be its chairman in succession to the late Viscount Addison.

SIR ANDREW MCCANCE has been appointed chairman of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research in succession to the retiring chairman, Sir Henry Guy.

LORD HANKEY has been elected to the Athenæum under the provisions of Rule II of the Club, which empowers the annual election by the Committee of a certain number of persons of distinguished eminence in science, literature or the arts, or for their public services.

THE Institute of Biology is arranging a symposium on "Biology as a Career" at the Heriot-Watt College, Edinburgh, on April 10, at which authoritative speakers will give present and future trends of biological development and opportunities. Further particulars will be available in due course from the Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1, and F. T. Walker, local secretary for Scotland of the Institute, Institute of Seaweed Research, Inveresk, Midlothian.

THE East Midland Centre of the Institution of Electrical Engineers is arranging a convention on "Contacts", which will be held at Loughborough College during April 7–9 and which will be open to non-members of the Institution. The programme will be divided into two sessions : the first on light-duty contacts in theory and practice; and the second on heavy-duty contacts, including contactors and sliding contacts (brushes). Further details can be obtained from Mr. R. G. L. Ryan, Brush Electrical Engineering Co., Ltd., Loughborough, Leics., or from Dr. J. H. Mitchell and Mr. R. C. Woods, Ericsson Telephones, Ltd., Beeston, Nottingham.

ON the invitation of the Royal Anthropological Institute, the International Congress of Americanists will hold its thirteenth session in Cambridge during August 18–23, accommodation being provided in one or more colleges of the University. This date has been arranged in consultation with the organizers of the International Congress of Anthropological and Ethnological Sciences, to be held in Vienna, so as to permit those who so desire to attend both Congresses. Further details can be obtained from the Joint Secretaries of the Organizing Committee, International Congress of Americanists, c/o University Museum of Archæology and Ethnology, Downing Street, Cambridge.

UNDER the provisions of the Fulbright Programme, travel grants are available to citizens of the United Kingdom and British Colonies to go to the United States for academic or educational purposes, provided that they have the financial support in dollars for the visit and are affiliated to an American institution of higher learning. The Fulbright grants cover the cost of travel from the candidate's home to America and return, and are available during June 1952–May 31, 1953. Applications must be submitted by March 15 (those travelling between June 1 and July 31) or June 15 (those travelling after August 1). Further details can be obtained from the United States Educational Commission in the United Kingdom, 55 Upper Brook Street, London, W.1.

IN *Nature* of December 29, p. 1106, a paragraph was printed referring to a Medical Research Council publication on pneumoconiosis. We regret to find, however, that the concluding sentence of this paragraph referred to another Medical Research Council publication, namely, "The Application of Scientific Methods to Industrial and Service Medicine", Proceedings of a Conference held from March 29th to March 31st, 1950 (H.M. Stationery Office, 1951; 3*s*. net).

NEW TYPE OF X-RAY EVIDENCE ON THE MOLECULAR STRUCTURE OF GLOBULAR PROTEINS

By Dr. D. P. RILEY and Dr. U. W. ARNDT
Royal Institution, London, W.1

THE striking successes of the methods of X-ray diffraction analysis as applied to single crystals composed of relatively small molecules have tended to turn attention away from the usefulness of less detailed analyses in the case of substances of high molecular weight and considerable complexity. The precise three-dimensional mapping of each atomic position achieved with small molecules is still beyond the realms of possibility where molecular units of the size of the globular proteins are concerned. The best that can be hoped for at this stage is the unequivocal establishment of a definite structural scheme for a class of protein molecules: we are seeking the master-pattern or skeleton of which the whole structure is an elaboration. As soon as we adopt this view, it is permissible to use experimental procedures which give directly an averaged picture of the molecule of an appropriately modest degree of resolution. Such a picture is afforded by the averaged distribution of matter radially within the molecule, and this can be derived from a knowledge of the intensity scattered over a wide angular range by the amorphous material. Considerable interest is attached to this simplified presentation of the structure because of the possibility of direct comparison with equivalent radial distribution curves derived by Profs. L. Pauling and R. B. Corey and based on the theories of protein structure recently, and so brilliantly, conceived by them[1]. We have just completed an investigation of this type for one protein, bovine serum albumin, and the results are sufficiently encouraging to be worthy of report here prior to a more extensive study of other proteins in various states.

The specimen used was prepared by freeze-drying a solution of bovine serum albumin (Armour Laboratories), a protein sample of considerable purity. A Geiger-counter spectrometer was used for measuring the intensity of scattering from this amorphous undenatured material over a range of $\sin\theta/\lambda$ from 0·025 to 0·6. The nickel-filtered copper radiation from a clean tube operated at 30 kV. D.C. was analysed with a calcite cleavage slip and shown to consist of 97 per cent copper $K\alpha$ in terms of total energy as recorded by the counter[2]. This constitutes an adequate degree of monochromatization. At each angular setting of the counter during a run, counts were taken: (*a*) with the specimen, enclosed in a cell with thin 'Cellophane' windows, in the beam; (*b*) with an identical but empty cell in the beam; (*c*) with nothing but air in the beam. These results, together with the appropriate linear absorption coefficients measured on the actual filled and empty cells, were used for deriving the intensity scattered by the protein alone. Measurements were taken both with the transmission and the reflexion arrangement of the flat sample, and the final corrected intensity curve (Fig. 1) represents the combined results of several runs of both types.

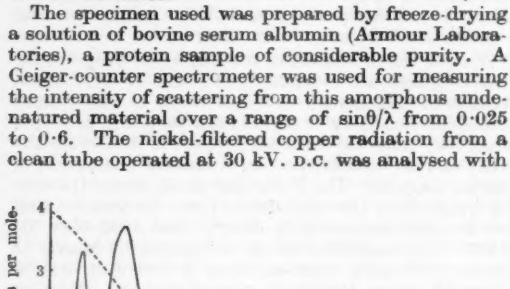


Fig. 1. Corrected intensity curve for amorphous bovine serum albumin. Dashed curve represents total independent scattering per molecule

In order to reduce this curve to a form amenable to Fourier analysis, it is necessary to know the approximate elementary composition of the specimen. For this purpose, we have used Osborne's analyses[3] for horse serum albumin adjusted to a water-content of 10 per cent and an anhydrous molecular weight of 70,000. The formula of the hydrated molecule is then $C_{2032}H_{3179}O_{1111}N_{794}S_{43}$. We have shown that the final result is not appreciably affected by reasonable changes in this formula. In Fig. 1 is shown the total intensity curve (coherent plus incoherent scattering) given by hypothetical material of this composition in which all the atoms are presumed to scatter independently; the agreement with the actual curve for $\sin\theta/\lambda$ from 0·5 to 0·6 shows that a sufficient range of this variable has been embraced in the experiment, although an extension to higher values would certainly be desirable. Again, the final result is not markedly dependent on the exact point chosen to fit the two curves.

The experimental curve can now be placed on an absolute scale of intensity. Following Warren, Krutter and Morningstar[4], we employ the transformed Zernike and Prins expression, modified for the hetero-atomic case, to derive the radial distribution function shown in Fig. 2. The actual function plotted is $4\pi r^2\{\bar{\rho}(r)-\rho_0\}$, where $\bar{\rho}(r)-\rho_0$ represents the deviation of the weighted mean electron density function $\bar{\rho}(r)$ from the average electron density ρ_0 (electrons per A.^{3}), and r is a distance in A. measured radially outwards from the centre of any atom. If the hydrated molecular formula be written as $C_pH_qO_rN_sS_t$, the weighted mean electron density function is defined by the following expression, the summation sign referring to the whole molecule:

$$\bar{\rho}(r) = \frac{1}{\Sigma K_M}\left[pK_C\rho_C(r) + qK_H\rho_H(r) + rK_O\rho_O(r) + sK_N\rho_N(r) + tK_S\rho_S(r)\right].$$

K_M, a constant chosen to represent the effective number of electrons in atom M, is an average value

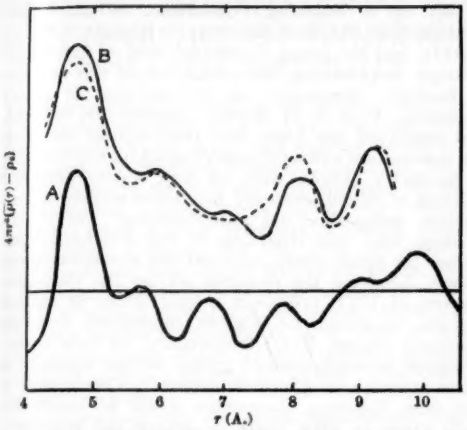


Fig. 2. Radial distribution curves: (*A*) experimental; (*B*) Pauling and Corey's 3·7 helix, β-carbon position 2; (*C*) β-carbon position 1

of f_M/f_e, where f_M is the atomic scattering factor for atom M and f_e is the average scattering factor per electron for the whole molecule. $4\pi r^2\rho_M(r)dr$ is the effective number of electrons (that is, number of atoms, each multiplied by its appropriate K_M) in a spherical shell of radii r and $r+dr$ measured from the centre of one M atom, and then averaged by considering each different M atom in turn as origin. $4\pi r^2\bar{\rho}(r)dr$, therefore, represents the weighted mean of the product of the effective number of electrons in the atom chosen as origin and the averaged total effective number of electrons from atoms of all types lying between distances r and $r+dr$ from the centre of that atom. In the protein case, the distinction between effective and actual numbers of electrons is slight, because of the predominance of atoms of nearly the same atomic number. The function $4\pi r^2\bar{\rho}(r)$ is therefore the spherically symmetrical analogy of the 3-dimensional Patterson function used in single-crystal work, if the latter is expressed in absolute units. If, however, only Patterson peaks rising above an average level of vector density are considered, then the integration over all orientations corresponds to $4\pi r^2\{\bar{\rho}(r)-\rho_0\}$, although the choice of ρ_0 may differ from the true average electron density in an actual case. Pauling and Corey, in fact, performed a numerical integration of the 3-dimensional Patterson synthesis of this type, published by M. F. Perutz[5] for wet crystalline horse methæmoglobin, in order to compare the resulting radial distribution curve with theirs.

The exact significance of the distribution functions published by Pauling and Corey is this. The calculated function represents $4\pi r^2\bar{\rho}(r)$ for a single helix, which is effectively equal to the differential function $4\pi r^2\{\bar{\rho}(r)-\rho_0\}$ when only one helix is considered[1b]. Their results and ours can therefore be compared directly. It will be seen from Fig. 2 that the radial distribution curve given by serum albumin is remarkably similar to that calculated by Pauling and Corey[1a] for the 3·7-residue helical configuration of the polypeptide chain with the inclusion of a β-carbon atom in position 2, according to their nomenclature. For ease of comparison, the two curves are reproduced on roughly the same ordinate scale but displaced so as to have reference to different zeros. The abscissæ, representing radial distances in A., are identical. The main peak at 4·8 A. is at exactly the same position in both curves, while the next three peaks in the experimental curve are all at slightly shorter r values, by about 0·25 A., than in Pauling and Corey's curve. The relative heights of the peaks are very similar, except that the 7-A. maximum is more pronounced in the experimental distribution function. It is this peak which is the principal distinguishing feature between Pauling and Corey's two related curves, both of which are reproduced in Fig. 2. We have also included in our drawing a peak at 9·9 A. Other peaks, not shown, occur at 1·4 A., 2·6 A., 3·7 A., 11·3 A., and 12·6 A. The first of these peaks agrees well with the average interatomic distance, 1·42 A., between nearest neighbours in a polypeptide chain, neglecting hydrogen but including the β-carbon atom. The next distance corresponds to a composition of the N—H. . . O hydrogen bond, *c.* 2·72 A., with the average distance of *c.* 2·5 A. between second-nearest neighbours in the helically-coiled chain. The third distance is approximately that between third-nearest neighbours.

The far-out peaks are predominantly due to distances between atoms in neighbouring helices and therefore give information on the overall dimensions of the helical structural units, including the *R*-groups or side-chains, and the manner of packing of these units. We associate the 9·9 A., 11·3 A. and 12·6 A. peaks with the principal inter-helix separations in the plane normal to the long axes of the helices. The clear resolution into three peaks indicates that the helices are better represented by elliptical than by circular cylinders, or that the cylinders are of different diameters. The average helix diameter is about 11 A. in both cases, corresponding to the value of 10·5 A. found by Perutz in horse methæmoglobin.

When regard is had to the approximations made on both sides, the agreement between theory and experiment over a considerable range of interatomic distances is striking and would seem to establish, with some certainty, Pauling and Corey's 3·7 α-helix structure, or a closely similar polypeptide chain configuration, as the correct one for bovine serum albumin. It even appears possible to decide between the two closely similar postulated structures, which differ only in the positions assigned to the β-carbon atoms of the side-chains. The 5·1 residue γ-helix can definitely be excluded. This kind of detailed comparison of radial distribution functions has been greatly facilitated by the fact that Pauling and Corey have carefully computed curves of the appropriate type for two of their models, even introducing the refinement of allowing for the distribution of electron density around the various atomic nuclei[1b]. It would clearly be desirable to derive curves for the topologically similar helical structures of Huggins[6], and of Bragg, Kendrew and Perutz[7], in order to compare them with experiment, and it is our intention to do this in the course of future investigations.

[1] Pauling, L., Corey, R. B., and Branson H. R., *Proc. Nat. Acad. Sci.*, **37**, 205 (1951). Pauling, L., and Corey, R. B., *ibid.*, **37**, 235, 241, 251, 256, 261, 272, 282 (1951). (*a*) *Ibid.*, 284, Fig. 2. (*b*) Private communication.
[2] Arndt, U. W., and Riley, D. P., *Proc. Phys. Soc.*, A, **65**, 74 (1952).
[3] Osborne, T. B., *J. Amer. Chem. Soc.*, **24**, 140 (1902).
[4] Warren, B. E., Krutter, H., and Morningstar, O., *J. Amer. Ceram. Soc.*, **19**, 202 (1936).
[5] Perutz, M. F., *Proc. Roy. Soc.*, A, **195**, 474 (1949).
[6] Huggins, M. L., *Chem. Rev.*, **32**, 211 (1943).
[7] Bragg, W. L., Kendrew, J. C., and Perutz, M. F., *Proc. Roy. Soc.*, A, **203**, 321 (1950).

MATHEMATICAL ASSOCIATION

ANNUAL GENERAL MEETING, 1952

THE annual general meeting of the Mathematical Association was held at the Polytechnic, Regent Street, London, during January 3 and 4, with the president, Dr. Mary L. Cartwright, Mistress of Girton College, Cambridge, in the chair.

In her presidential address, "Non-linear Vibrations: a Recent Chapter in Mathematical History", Dr. Cartwright described the development of work on those problems of applied mathematics which lead to non-linear differential equations, of the type which cannot be solved explicitly. Encountered by Poincaré in celestial mechanics, these equations came into greater prominence about 1920 with the work of van der Pol and Appleton on radio circuits; since then, radio engineering has increasingly demanded research on non-linear equations, particularly on the main problem of the existence of 'steady states', that is, of periodic or approximately periodic solutions. In the 1930's a Russian group of mathematicians, including particularly Kryloff and Bogoliuboff, developed very general methods of attack, not, however, very easily accessible to Western readers. Slightly later, Prof. J. E. Littlewood and Miss Cartwright in Great Britain and Prof. N. Levinson in the United States showed that topological arguments can be applied to the 'phase plane' of $(x, dx/dt)$ to enable inferences about the periodic solutions to be made. The whole field is scattered with unsolved problems which should provide material for research for many years to come.

It was in January 1902 that the Mathematical Association first appointed a Teaching Committee, and it was therefore fitting that much of the 1952 meeting should be devoted to matters which are dealt with for the Association by its Teaching Committee, such as the long series of "Reports", both on the teaching of special subjects, and on methods appropriate to special types of pupil. During the afternoon of January 3, a discussion on "The Association's Reports" was opened by Mr. J. T. Combridge, the present chairman of the Teaching Committee. Mr. Combridge described the gradual widening of the Association's interests so as to include on one hand increased correlation with university teaching, and on the other a deeper understanding of and interest in the teaching of mathematics in 'modern' and technical schools. Mr. A. W. Riley dealt in more detail with this latter aspect of the Association's plans, and Prof. T. A. A. Broadbent outlined the complementary functions of the Association's two main sets of publications, the Teaching Committee's Reports and the *Mathematical Gazette*. In the open discussion, many members pleaded for a new report in which school mathematics should be treated as a unified subject, not as a collection of separate topics.

The Association is proud to number among its still very active members two who served on the first Teaching Committee in 1902, Mr. A. W. Siddons and Mr. C. O. Tuckey. In an hour of reminiscences, Mr. Siddons told how in the early years of this century the plea of Prof. John Perry for a reform of mathematical teaching and the work of the British Association's committee on this topic prompted a letter from twenty-three schoolmasters, including Charles Godfrey and himself, urging the serious consideration of reforming projects, and thus causing the Association to set up a Teaching Committee, of which Mr. Siddons was the first secretary. Reports followed quickly, and the young committee won its first major triumph in procuring the overthrow of the tyranny of Euclid's "Elements" as the autocrat of school geometry. Prof. E. H. Neville followed Mr. Siddons, and described the ideas and personalities inspiring the Association's revolutionary report on the teaching of geometry (1923), with its now widely accepted division of school geometry into three stages, experimental, deductive, and systematizing. Mr. C. O. Tuckey, who was chairman of the Teaching Committee for many years, outlined the strenuous work, which, following the example set by the Geometry Report of 1923, produced a long series of subject reports, on arithmetic, algebra, mechanics, a second geometry report, and trigonometry, all now widely accepted as authoritative guides to the teaching of these subjects in grammar schools. The jubilee of the first Teaching Committee could be celebrated with pride in fifty years of severe but successful struggle for a reform of the teaching of mathematics in Great Britain.

On the morning of January 4, the first item was a discussion on the use and mode of teaching of vector methods, opened by Mr. K. Wardle and Mr. P. J. Wallis. Mr. R. H. Cobb then spoke on "Syncopated Geometry", describing how a calculus of functional symbols can be applied to the geometry of the triangle.

In the afternoon, a discussion took place on the recently published report of the Association on the teaching of calculus in schools, prepared by the Teaching Committee, under the chairmanship of Mr. K. S. Snell. Calculus is now taught in most schools, very often being begun in the fifth form, and is not confined to those pupils who are specializing in mathematics or natural science. Thus, in a first course, a variety of methods of approach must be available and must include one suitable for those pupils whose chief interest is on the side of the humanities. Mr. Snell described the ideas behind those chapters of the report which deal with the first course, and Dr. I. W. Busbridge then dealt with the more advanced chapters, which cover the whole range of the work in calculus likely to be done in schools by any but the ablest specialists. The aim of these later chapters is to keep the exposition as simple as possible, but yet to teach the pupil nothing which he or she will have to unlearn at a university. The idea of providing a firm bridge from the school course to the university course is in keeping with the Teaching Committee's recognition that the Association must increasingly co-ordinate its views with those of the universities. In the open discussion, some criticism of the omission of any reference to infinite series was made, but it was explained that the Association has in view a further report on sixth form analysis, in which this topic will more naturally find a place, as will other advanced matters such as the introduction of irrational numbers.

In the evening of January 4, Mr. A. W. Fuller gave a paper on "Some Measuring and Computing Devices of Interest to Teachers in Secondary Schools of all Kinds", of particular value now that the position of statistics as a school subject is receiving serious consideration.

The next annual general meeting of the Association will be held at Sheffield in April 1953. The president for the present year is Mr. K. S. Snell, of Harrow.

FIRST INTERNATIONAL CONFERENCE OF PRINTING RESEARCH INSTITUTES

IT is no easy task, in science as in politics, to convene an international meeting, but in science the results are invariably worth while; and the first International Conference of Printing Research Institutes proved no exception to this rule and well justified the effort put into the general arrangements for receiving delegates from France, Denmark, Holland, Sweden and Western Germany for the three-day period of the Conference, held during November 26–28. Such a conference has been long overdue, and it may be said that success attended it, the general desire being to hold a second conference, in early 1953, in Stockholm by courtesy of the Grafiska Forskningslaboratoriet, when it is proposed to discuss "The Printing Properties of Paper".

As is usual on such occasions, considerable benefit was obtained from personal contact with workers in similar fields, and it was possible, Conference agenda apart, for research workers to get to grips jointly on their different problems—always preferable to corresponding with just a name.

The first day of the Conference was devoted to a tour of the laboratories of the Printing, Packaging and Allied Trades Research Association (Patra) and to a general discussion on the organization of printing research institutes, to which contributions were made by G. L. Riddell (Patra), G. E. Carlsson (Sweden), J. F. Monroy (Holland), E. E. Andersen (Denmark), A. Bargilliat (France) and J. Albrecht (Western Germany). There appeared to be a surprising degree of uniformity of organization and programmes, coupled with a not surprising shortage of both finance and scientific man-power.

The second day, given over to papers and discussion of the physics of letterpress printing, was opened by G. E. Carlsson and L. Pihl (Sweden), who reported that preliminary results of their work indicated that the dynamic pressure generated on printing elements is mainly determined by their size and distance from other elements. The pressure generated by penetration of printing elements into the elastic cylinder covering is greater for a small than a large element, the pressure increasing as a linear function of the speed of printing. Lubrication by the printing ink decreases the pressure.

R. G. Croney (Patra) reported on the mean pressure generated on printing elements of different sizes and shapes when they penetrate the elastic cylinder covering of the printing machine. This pressure varies inversely with the radius of the printing element, because the volume of the cylinder covering compressed by the penetrating element extends beyond the perimeter of the element and is proportionately greater for small elements than for large. The occurrence of high pressures at the edges of printing elements can be predicted mathematically, and demonstrated by making prints from sensitive carbon paper or by the rounding of the edges of type and other printing elements during use. The fidelity of reproduction without 'make-ready' from soft rubber and thermoplastic printing plates has been shown to give a better correlation with dynamic resilience than with measurements of static hardness.

The application of the work to 'make-ready' (the rough equalization of pressures by hand manipulation), which may render half the useful life of a commercial printing machine unproductive, was discussed. Describing the uses of limit gauges in pre-make-ready, J. F. Monroy (Holland) demonstrated a newly designed gauge for indicating the correct thickness of the cylinder packing, the instrument being in two halves and fitted with a dial to record the relative displacement of the two sections when the gauge passes through the printing machine. Monroy also described the method developed in Holland for determining the best screen-ruling for half-tone plates. The screen depends on the surface characteristics of the paper, the fineness of grinding of the printing ink, the ink film-thickness and the printing density required. The screen to be used for a given set of printing conditions is determined by using a controlled proof-printing technique. An empirical formula relating the screen ruling with the density of the print at a given ink film thickness has been derived.

On the final day of the Conference, which was devoted to ink drying, R. R. Coupe and A. H. Smith (Patra) dealt with the penetration of oil from ink into paper, the final depth of penetration being measured by two methods, namely, by measuring the volume of unfilled voids in the paper by absorbing a liquid such as oleic acid, extracting and analysing, or by cutting a thin section of the print at right angles to the plane of the paper and measuring the depth of penetration by means of a microscope. In this latter method the paper is embedded in polyethylene and the section taken with a microtome and stained with iodine. Results indicate that the distance of penetration into the paper is linearly related to the thickness of the ink film applied, and it has been shown that the separation of varnish from the ink after printing is determined to a large extent by the capillary structure of the paper on which the print is made. Reflectance methods for measuring the rate of penetration of oil from inks into paper were also outlined.

G. E. Carlsson and L. Pihl reported a statistical analysis of their data on the height of rise of viscous oils up strips of paper and the time taken for oil to penetrate the paper in a direction at right angles to the surface (oil flotation number). There is a linear relationship between the reciprocal of the oil flotation number and the square of the height of rise, and the results indicate large differences in the main capillary pore sizes in the two paper directions.

Carlsson and Pihl also reported some observations made on the factors influencing the drying of lithographic printing inks. There is evidence that the water used in lithography emulsifies with the ink, and certain additions commonly used in the damping water, notably phosphates, react with the metallic soap driers in the inks. A new drier based mainly on calcium perborate was described.

The final papers were read by R. R. Coupe (Patra) on the inhibition of drying of lithographic varnishes by acid and salt solutions and on the influence of the paper on drying. The mechanism of inhibition is the extraction of the drier metal from the varnish by the aqueous salt solution, and this is highly dependent on the anion present and on the *p*H. Phosphates, sulphates, citrates and low *p*H values favour inactivation of the drier metals. Nitrates, chlorides and chromates have little effect.

Paper can slow down the drying of varnish containing metal soaps, and this is probably associated with the adsorption of the drier metal on the cellulose fibres. If linseed oil containing cobalt soaps is allowed

to rise up a strip of paper and the paper afterwards developed with Nitroso-*R* salt, it can be shown that cobalt is adsorbed on the lower part of the strip, the oil being denuded of drier. Acid papers adsorb the cobalt more strongly. The adsorption is irreversible and probably involves the hydrolysis of the cobalt soap or an ion exchange process between the soap and the cellulose. The rate of adsorption is slow, and the amount adsorbed at any given time is proportional to the square root of the time.

Arrangements are being made for the publication in full of the papers read and the ensuing discussions.

G. L. Riddell

CORROSION OF BURIED METALS

A SYMPOSIUM on the corrosion of buried metals was held jointly by the Iron and Steel Institute, the British Iron and Steel Research Association and the Corrosion Group of the Society of Chemical Industry in London on December 12. Sir Charles Goodeve was in the chair, and about three hundred people attended. Preprints of the papers under discussion were circulated before the meeting.

In his opening remarks, Sir Charles Goodeve said that modern communities are dependent on a number of services, of which the chief are water, gas, electricity and sewage, and the corrosion of underground pipelines or cables conveying these is a problem of great magnitude. He referred to the report of the Ministry of Health Departmental Committee on the Deterioration of Cast Iron and Spun Iron Pipes published in 1950. This report stressed the need for further research, and the work had been entrusted to the British Iron and Steel Research Association's Sub-Committee on the Corrosion of Buried Metals formed in March 1950. Represented on this Sub-Committee were manufacturers and users of ferrous and non-ferrous materials, gas and water engineers and others, so that a very satisfactory representation and co-ordination of the interests concerned had been achieved. One of the earliest actions of the Sub-Committee was to make plans for the present symposium.

In the first session the papers discussed were "Tests on the Corrosion of Buried Iron and Steel Pipes" by J. C. Hudson and G. P. Acock, and "Investigations on Underground Corrosion" by K. R. Butlin, W. H. J. Vernon and L. C. Whiskin. In introducing the first paper, Dr. Hudson gave a brief survey of the events leading to the research, and Mr. Acock described the interim results contained in the paper. The second paper was introduced by Dr. Vernon.

Dr. W. F. Higgins, opening the discussion, questioned the value of tests using short lengths of pipe, and pointed out that variations in the composition of the soil along the length of a pipe could, by a concentration-cell effect, lead to corrosion at certain places. Such effects were not reproduced in the tests described, which could not, therefore, purport to indicate the behaviour of pipe-lines. Mr. W. G. Waite supported this contention and mentioned a number of other ways in which the test conditions were different from those of practice. He felt that additional useful information would have been provided by measurements of the loss of mechanical properties of the materials buried, and determinations of the conductivities of soil waters. Mr. N. J. Pugh was also doubtful about the value of tests on short lengths. He mentioned several factors occurring in practice which could affect the course of corrosion, particularly the setting up of internal stresses by pressure fluctuations in water mains. Sir Charles Goodeve afterwards commented on these criticisms of the use of small specimens and pointed out that similar problems arise in many branches of scientific work. It is a fact, he said, that the accuracy of measurement falls off as the scale of the experiment increases, until on the full scale the accuracy is usually too low to give useful results owing to the presence of uncontrolled variables. Furthermore, the cost of experiments rises sharply as the scale increases. A compromise is desirable where accuracy of measurement, correspondence to practical conditions and cost are all at reasonable levels.

A number of speakers discussed the merits and disadvantages of various protective coatings or schemes. Mr. Hussey pointed out that certain soils are not corrosive, as shown by the condition of excavated museum specimens, and thought that certain clay-chalk mixtures might be used to give protection. Mr. Warner described how 6 in. of puddled clay around buried tanks used for storing petroleum products had kept the tanks in relatively good condition for more than sixty years, connecting pipe-lines having been much more severely corroded. Mr. E. W. Rawlings said that latex cement, which can be applied by spraying, has been successfully used.

Dr. F. Wormwell gave some details of work in progress at the Chemical Research Laboratory, Teddington. Electrochemical measurements are being made to throw more light on the mechanism of microbiological corrosion. It has been found that this type of attack can be prevented by cathodic protection. Earlier Mr. Waite had expressed the view that perhaps too much emphasis had recently been given to the part played by bacteria in corrosion, and in the course of his reply to the discussion Dr. Vernon said that he and his colleagues have taken every opportunity of pointing out that microbiological corrosion is not basically different from electrochemical corrosion, of which it is merely a special type. He stressed that, contrary to the views expressed by one or two speakers, a noteworthy feature of soil corrosion research is the close co-operation that has been established between research workers and users. Mr. L. C. Whiskin, chairman of the Sub-Committee on Corrosion of Buried Metals, referred briefly to the current activities of the Sub-Committee.

In the second session the two papers discussed were "Cathodic Protection" by K. A. Spencer and "Cathodic Protection of Buried Metal Structures" by R. de Brouwer. Mr. Spencer introduced both his own paper and that by M. de Brouwer, who was unfortunately prevented from attending. During the course of his introduction, Mr. Spencer showed a short film on the laying of an oil pipe-line in Scotland, illustrating the installation of magnesium anodes.

Several speakers stressed the low cost of cathodic protection and its high efficiency in preventing corrosion. Mr. C. W. Marshall mentioned successful applications of the method in Belgium and Holland, and Dr. A. J. Maurin described its application in France. He distinguished between specific aggressivity and apparent aggressivity over the length of a pipe-line, and said that nomograms have been constructed for calculating specific aggressivity from certain soil

characteristics. Cathodic protection is being applied to some 600 km. of new gas mains every year. Mr. C. W. N. McGowan described a cathodic protection installation for jetty piling in the Persian Gulf, and Mr. H. C. S. Hayes gave details of the experience of the General Post Office. Corrosion of lead-sheathed cables in earthenware ducts is widespread, and although this can be prevented by wrapping with impregnated hessian tape, this solution to the problem is not attractive owing to its expense and the space taken in the duct. Preliminary tests of cathodic protection have been successful.

A number of speakers discussed the techniques of measuring pipe/soil potentials using copper/copper sulphate reference electrodes, and the significance of the results obtained. Mr. J. H. Gosden showed how such measurements had facilitated the diagnosis of corrosion of lead-covered cables which had been caused both by stray currents from an adjacent traction system and by electrolytic action. Mr. Spencer briefly replied to the discussion.

The third session was devoted to the following papers: "Corrosion of Buried Copper and Ferrous Strips in Natural and Salted Soils", by the British Electrical and Allied Industries Research Association, and "Tests on the Corrosion of Buried Aluminium, Copper and Lead", by P. T. Gilbert and F. C. Porter. The first paper was introduced by Dr. G. Mole and the second by Mr. Porter.

Dr. F. A. Champion considered the results in the first paper could have been better presented in the form of a simple plot of corrosion against time. He agreed that the effect of salting, as sometimes carried out when earthing plates are installed, is largely confined to increasing corrosion in the early life. Regarding the second paper, he considered that the presence of relatively large amounts of chloride and sulphate is not in itself an adequate explanation of the corrosion of aluminium, and suggested that more attention should be paid to the question of the copper content of the soil waters. He referred briefly to the results of some tests carried out by his colleagues, which showed that a protective scheme incorporating barium chromate as inhibitor gave promising results on aluminium specimens buried for two years in cinders.

Mr. Gosden drew the general conclusion that bare copper is normally adequately resistant to soil corrosion, that aluminium should not be buried without a good protective coating and that the position of lead is intermediate. He gave details of the experience of the British Electricity Authority with 130,000 miles of lead-sheathed cable. In 1949, 106 faults occurred, of which sixty-three were due to electrolytic action and twenty-seven to chemical action of various types. Mr. J. B. Cotton mentioned the danger of accelerated attack at defects in a tin coating on copper.

Mr. E. A. G. Liddiard thought clad aluminium alloys have possibilities. In reply to his query about experiments to follow corrosion by change in electrical resistance, Dr. Hudson said that plans for such experiments had been well advanced but circumstances had necessitated their abandonment. Mr. R. L. Davies described some experiments which suggested that aluminium could corrode rapidly in anaerobic conditions.

Dr. Mole and Dr. Gilbert replied briefly to the discussion.

The papers on which the discussion was based and a full account of the discussion will be published in due course by the Iron and Steel Institute.

NATIONAL RESEARCH COUNCIL OF CANADA

ANNUAL REPORT FOR 1950-51

THE thirty-fourth annual report of the National Research Council for 1950–51* includes the report of the president, Dr. C. J. Mackenzie, the Financial Statement and a financial statement and summary of the operations of Canadian Patents and Developments, Ltd., for the year ended March 31, 1951.

In the Division of Applied Biology the macromolecule laboratory is investigating the size, shape and charge of several carbohydrate extracts of marine algæ, upon which their industrial value depends, and the microbial decomposition of cellulose is also being studied with the view of the utilization of industrial wastes. In the plant science section the mechanism of photosynthesis and particularly the transformation of absorbed light energy into chemical energy or reducing power is being investigated, while the industrial fermentations group has found that *Pseudomonas hydrophila* is superior to all other organisms for the production of 2 : 3-butylene glycol from sulphite waste liquor or from beet molasses. Re-designing the overhead bunkers in the standard railway refrigerator-car by extending the cooling surface with fins and improving the air circulation has resulted in a reduction of the air temperature in the car by 4·5° F.

Work on marine products has been concluded, and the project will be transferred to the Maritime Regional Laboratory. Conditions for extracting alginates from Canadian seaweeds were established, and soluble chitosans obtained by deacetylating chitin from lobster shells. In the Prairie Regional Laboratory, Saskatoon, work was continued on the fermentation of sugars by the corn-smut fungus, *Ustilago zeæ*, and studies were continued on the production of glycerol with *Bacillus subtilis* to establish the conditions giving rapid fermentation with consistently high yields from a starch substrate. The possibility of using mould enzymes for solubilizing or modifying materials which contain protein is being studied as well as the formation of lignin in wheat plants, and work was continued on spray-drying wheat gluten.

In the Division of Chemistry a specially designed ultrasonic interferometer has been used to measure the velocity and absorption of sound in the region of the liquid-gas critical temperature. While the photoconductivity of anthracene was confirmed, no photoconductivity was observed for octadecane. More information has been obtained on the shape factor of the individual particles and agglomerates in thixotropic suspensions from the rheological properties of the systems as a whole. Elucidation of the structure of the lupin alkaloid thermopsine has supplied the key to the structure of two new alkaloids, α-*iso*sparteine and α-*iso*lupanine, while progress is reported in the interpretation of infra-red spectra of fatty acids. In applied chemistry the pilot-plant work on the recovery of oil from Alberta bituminous sands has continued, and a combination of water separation with flash distillation in a fluidized bed appears likely to provide an economic process for the recovery of oil from such sands. Besides investigations on the causes of normal corrosion in domestic hot-water heaters and the cooling-systems of internal com-

* Thirty-fourth Annual Report of the National Research Council of Canada, 1950–51. (N.R.C. No. 2468.) Pp. 43. (Ottawa: King's Printer, 1951.)

bustion engines, fundamental work has been carried out on the mechanism of corrosion inhibition and the rate of oxidation of heat-resistant alloys at high temperatures. Identification of the constituents of Canadian marine and vegetable oils was being continued in part with the view of alternative sources of drying-oils, and laboratory work on a new silver catalyst for the production of ethylene oxide was nearing completion.

In the Division of Physics a Collins liquid-helium cryostat has been installed, while the acoustics group has done much to supply the operational maintenance of the improved marine fog-horn already developed. Using the photographic emulsion technique, a study of very high-energy nuclear disintegrations caused by incoming primary cosmic-ray particles has provided evidence that both neutral and charged mesons are produced in the interaction between such incoming particles and the elementary nucleons (neutrons and protons) which make up atomic nuclei. Using the counter technique an accurate comparison has been made of the intensities of cosmic rays continuously recorded at Ottawa and at Resolute. In the radiology laboratory trial sources of radioactive cobalt have been investigated to obtain information required for the design of radiation therapy equipment using very large radioactive sources, and a method has been developed for measuring the energy output and obtaining the isodose curves of beta-ray plaques used in some types of cancer therapy. Experimental work on the determination of the acceleration due to gravity by direct observation on a falling body continued in the metrology laboratory. The optics laboratory developed a new method, using the Herschel effect, for increasing the effective range of photographic papers, while the spectroscopy group analysed the infra-red spectra of nitrous oxide and heavy methylacetylene and elucidated their molecular structure. In theoretical physics, a systematic study was made of the quantization of the classical theory of charged particles with spin, and the validity of the usual perturbation theory in the auto-ionization of light atoms was studied; calculations of the probabilities of excitation of vibrational states of hydrogen by electrons, protons and hydrogen atoms were made and theories developed for the ferro-electric effect of certain crystals and the dissociation of oxygen molecules in the upper atmosphere.

Housing has continued to dominate the selection of projects for investigation by the Division of Building Research; but jointly with the Division of Chemistry an extensive programme of corrosion research is in operation as well as one on paint failures, and a detailed survey of fire research needs in Canada and of fire research and testing facilities in North America was approaching completion. In the Division of Mechanical Engineering, wind-tunnel studies have been made on four Canadian aircraft, while the work of the model-testing basin was expanded and included tests of naval vessels. Factors affecting ice formation on large bodies of water were studied in connexion with the possibility of maintaining ice-free navigation channels in winter, as well as ice crystal formation in fuels and the operational behaviour of low-temperature lubricants.

The programme of the Radio and Electrical Engineering Division comprised about thirty projects in electrical engineering, electronics, radar and radiophysics. A new marine radar with the minimum range of only ten yards was developed, which gave excellent performance, especially in small harbours, in passing ships at close quarters and in docking; and other developments included a microwave shore beacon for use with a simple inexpensive microwave receiver on board ship, a radio-frequency mass spectrometer which employs no magnetic field, an experimental electron accelerator as a source of beta- or gamma-rays with an energy of four million volts, and a new surge generator and a 400-kW. pulse-generator providing extremely bright flashes of light, lasting a few microseconds, at 5–500 times a second. A theoretical study of servo-mechanism performance based on a generalized frequency-response analysis was completed and the infra-red detector used to locate faulty joints on power-transmission lines redesigned. In the Atomic Energy Project, using the electron-pair, neutron and beta-ray spectrometers, new energy-levels have been found in the nuclei of several atoms, and the structure of certain compounds, such as deuterized ammonium chloride and carbon tetrachloride, has been determined. With the new high neutron flux available in the field, new isotopes have been obtained by successive capture of neutrons.

SUMMER DAY-TIME METEOR STREAMS OF 1949 AND 1950

UNDER the general heading of "The Summer Daytime Meteor Streams of 1949 and 1950", three papers, each dealing with a different aspect of these daylight meteor streams, have recently been published*. The first paper, by A. Aspinall and G. S. Hawkins, describes the method of measurement of the radiant positions and activity. The original single-directional aerial, movable in azimuth, was unsuitable for a general survey of meteor radiants, and a new apparatus has been designed consisting essentially of two fixed, narrow-beamed aerials directed along azimuths 242° and 292° E. of N., operating on a wave-length of 4 m. As the radiant of an active shower moves across the sky, it produces echoes in each aerial in turn, and these echoes are recorded by continuous photography; from their range-time variation the right ascension and declination of a major shower can be determined to within ± 1·5°. Table 2 of this paper gives a comparison of the radiants of four streams from 1947 to 1950; these include the η-Aquarids—the well-known stream established by visual methods and which is supposed to be associated with the debris of Halley's Comet—and also the β-Taurids, the ζ-Perseids and the Arietids. The last two occur simultaneously and were not successfully interpreted with the single aerial; but the streams have been definitely separated with the new apparatus. In addition to these permanent streams, there are several others which are very active but are of a transient or long-period character, and there are numerous meteors which the apparatus in use fails to assign to any definite radiants.

The second paper, "Measurement of the Velocities", by J. G. Davies and J. S. Greenhow, explains how the radio-echo diffraction technique is used to determine meteor velocities. A description of this apparatus appeared in *Nature*, **161**, 596 (1948), and a short account of the method used is given in the paper. Tables 1 and 2 contain the lists of velocities obtained in 1950 and 1949 respectively, and other relevant information. The velocity distribution for

* *Mon. Not. Roy. Astro. Soc.*, **111**, No. 1 (1951), communicated by Prof. A. C. B. Lovell, Jodrell Bank Experimental Station, University of Manchester.

each shower shows an appreciable spread about the mean, the significance of which is discussed in the third paper, "Computation of the Orbits", by Mary Almond.

The radiant co-ordinates and velocities of four streams—the o-Cetids in addition to the three others already mentioned—provided the data for the computation of orbits, radiant positions being corrected for zenith attraction and diurnal aberration. Table 2 of the third paper gives the orbital elements and also the duration of the showers, which varied from 8 to 18 days. As might be expected, the radiant position was found to shift from day to day, but as there was no detectable change in the meteor velocities during these periods, the mean radiant positions and the most probable velocity values were used during the time of the activity of each shower. The table gives the spread of the orbital elements, which was estimated by considering the effects of a movement of the radiant within the given limits, and also of the probable spread of the velocity; a short discussion of the spread in each of the orbital elements follows. The orbits of the different showers, projected on the plane of the ecliptic, are shown, all of them being short-period orbits; in the β-Taurids and Taurids only does the semi-axis major of the orbits exceed 2 astronomical units, and Whipple has associated the latter with Encke's Comet. None of the others has been connected with cometary orbits, but their orbits have a close resemblance to some of those of the minor planets. It is interesting to note that in 1937 Hoffmeister suggested in "Die Meteore" that some meteor streams were associated with planets as well as with comets.

WORK OF THE WORLD HEALTH ORGANIZATION

THE beneficent activities of men of science are many and various; but few are more beneficent than those of the many experts all over the world who serve the United Nations World Health Organization. The *Bulletin*, the *Chronicle* and the Technical Reports of the Organization are so well known by now that it is not necessary to direct attention to them. They have, indeed, become so familiar that some of us perhaps fail to appreciate the width of the field they cover and the intensity of labour and the devotion to human welfare that they represent. "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition." These words, quoted in an address by the deputy director-general of the World Health Organization, Dr. P. Darolle, are taken from the preamble to the constitution of the Organization; and no one can read the successive publications of the Organization without acknowledging gratefully that everyone who serves it, from the director-general to the humblest field-worker, is translating these words into unremitting practice all over the world, and that this devoted work is taking effect on a great variety of sources of ill-health. Antibiotics, health statistics, childhood diseases, yellow fever, mental health, hygiene of seafarers, nursing, nutrition, rabies, brucellosis, rickettsioses, tuberculosis and tropical diseases of all kinds—these are only some of the subjects of the growing list of technical reports issued by the Organization. They all represent the work of committees of experts drawn from all over the world. It is perhaps invidious to select any one of these reports for special comment; but brief notes on four examples of them will indicate their range and value.

Part 1 of a publication entitled "Annual Epidemiological and Vital Statistics, 1939–46"* deals with the vital statistics and causes of death and covers the difficult years 1939–46, when war conditions made the compilation of vital statistics especially difficult; it links up with, and on the whole follows the pattern of, the annual epidemiological reports issued by the Health Organization of the League of Nations, the last volume of which appeared in 1941. This first part supplies, in respect to a number of countries and for the period 1921–46, information on total area, latest available census results, estimated population, birth- and fertility-rates, gross and net reproduction-rates and general and infant mortality-rates. In addition, it gives neo-natal mortality-rates for the period 1931–46 and mortality by cause of death in thirty-three countries from the pre-war period until 1946. There is also similar information for large towns. Changes in the revised international lists of causes of death adopted in 1938 are explained.

An example of the work of the World Health Organization taken from another field is the report of "Joint W.H.O./F.A.O. Expert Group on Zoonoses: Report on the First Session"†. At this first session, held in Geneva in December 1950, this group defined zoonoses as diseases which are naturally transmitted between vertebrate animals and man, and it discussed bovine tuberculosis, *Q* fever, anthrax, psittacosis and hydatidosis and their control. The report contains notes on international action for the study and control of other major zoonoses, together with a useful list of these diseases.

More specialized than the above-mentioned works are Nos. 38‡ and 39§ of the Technical Report Series. Report No. 38 records the proceedings of the conference of international experts held in December 1950 at Kampala, Uganda, which discussed especially the problems of malaria in Africa, where the chief vectors of malaria are *Anopheles gambiæ* and *A. funestus*, the former being much the more important. The other report gives an account of the proceedings of the expert committee which went into session at Kampala immediately after the meetings of this conference. It discusses the malaria policy of the World Health Organization, the control of malaria in Africa south of the Sahara, its control by residual spraying, and also insecticides and strains of insects resistant to them, and the prevention of transport of vectors by aircraft. The therapeutics of malaria is also discussed.

With these and the other reports and publications of the World Health Organization at hand, anyone interested in the world-wide fight against ill-health of all kinds can keep in touch with every aspect of this never-ending war. He can also see, by reading between the lines, glimpses here and there of the volume of hard work and devotion to human welfare that make all this detailed work possible. There can scarcely be, in any walk of life, a worthier record of human devotion to the welfare of mankind.

G. LAPAGE

* Annual Epidemiological and Vital Statistics. Part 1: Vital Statistics and Causes of Death. Pp. 124. 1951. 20*s*.

† Joint W.H.O./F.A.O. Expert Group on Zoonoses: Report on the First Session. (W.H.O. Technical Report Series, No. 40.) Pp. 48. 1951. 2*s*. 3*d*.

‡ Malaria Conference in Equatorial Africa. (W.H.O. Technical Report Series, No. 38.) Pp. 72. 1951. 3*s*. 6*d*.

§ Expert Committee on Malaria: Report on the Fourth Session. (W.H.O. Technical Report Series, No. 39.) Pp. 32. 1951. 1*s*. 6*d*.

(Geneva: World Health Organization; London: H.M.S.O.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Is there an Æther ?

In his recent communication[1] Prof. Dirac has said that in his new formulation of electrodynamics[2] a preferred motion exists at each point of space.

A preferred motion is also given at each point of space by cosmological observations (apparent isotropy of distant red-shift effects).

It is of interest whether any local physical effects are associated with this cosmologically preferred state of motion, and the analogous question can be asked with respect to Dirac's formulation. We have argued[3] that the first question may be answered in terms of the theory of continual creation (the steady-state theory of the universe), where the cosmologically preferred motion is identified with the velocity of newly created particles. Dirac answers the second question by saying that a small charge placed into a vacuum would possess the particular velocity associated with the potentials in his theory. The concept of introducing a charge into a vacuum, without fields destroying the vacuum character of the region, is given physical reality in a theory of continual creation.

H. Bondi

Faculty of Mathematics,

T. Gold

Cavendish Laboratory,
Cambridge.
Dec. 1.

[1] Dirac, P. A. M., *Nature*, **168**, 906 (1951).
[2] Dirac, P. A. M., *Proc. Roy. Soc.*, A, **209**, 291 (1951).
[3] Bondi, H., and Gold, T., *Mon. Not. Roy. Astro. Soc.*, **108**, 252 (1948).

A few remarks may clarify the relationship of the æther velocities in Bondi and Gold's theory and in mine. Where matter exists, both theories require it to have the æther velocity. Where there is no matter, Bondi and Gold interpret the æther velocity as the velocity of the matter which gets created by their process of continual creation. I interpret it as the velocity which a small electric charge would have if it were introduced. Now an electric charge cannot be introduced without violating the law of conservation of electricity, so one may wonder whether this velocity has any meaning.

Modern dynamical theory is founded on variation principles. A variation principle requires one to make a small change in the physical conditions, thereby violating some of the laws of Nature, and studies its effect on the equations of motion. *The more powerful the variation principle, the greater the number of laws of Nature which are considered to be violated.*

With my new theory some of the violations involve the creation of small charges. The theory does not allow the velocity of these charges to be arbitrary, but makes it quite definite, and so provides an æther velocity.

P. A. M. Dirac

St. John's College,
Cambridge.
Dec. 15.

Dirac's New Electrodynamics

The content of Dirac's[1,2] beautiful new classical theory of electrodynamics can be clarified by consideration of the energy and momentum tensor.

In Dirac's gauge, the potentials A^μ satisfy

$$A^\mu A_\mu = k^2 \quad \text{or} \quad A_0^2 = k^2 + \mathbf{A}^2;$$

and the Lagrangian

$$\mathcal{L} = -\tfrac{1}{4}\int F_{\mu\nu}F^{\mu\nu}\,d^3x = \tfrac{1}{2}\int (\mathbf{E}^2 - \mathbf{H}^2)\,d^3x$$

may be treated as a function of co-ordinates $\mathbf{A}$ to yield total field energy and momentum :

$$\mathcal{H} = \int \{\tfrac{1}{2}(\mathbf{E}^2 + \mathbf{H}^2) - A^0 \operatorname{div}\mathbf{E}\}\,d^3x,$$
$$\mathbf{P} = \int (\mathbf{E}\times\mathbf{H} - \mathbf{A}\operatorname{div}\mathbf{E})\,d^3x.$$

The first terms in $\mathcal{H}$ and $\mathbf{P}$ are the energy and momentum of the Maxwell field, the second represent an energy-momentum density of amount :

$$-A^\mu \operatorname{div}\mathbf{E} = -\rho A^\mu = (-\rho/e)\,mv^\mu,$$

where ρ is defined as div $\mathbf{E}$, and $v^\mu = (e/m)\,A^\mu$. If $(m/e)^2 = k^2$, v^μ is Dirac's four-velocity satisfying $v^\mu v_\mu = 1$. This is the energy-momentum density of a gas of particles with charge to mass ratio $-e/m$ and velocity distribution v^μ, treated as a continuous fluid. In agreement with this interpretation the field equations derived from $\mathcal{L}$ are Maxwell equations with current density :

$$\mathbf{j} = A_0^{-1}\mathbf{A}\operatorname{div}\mathbf{E} \quad \text{or} \quad j^\mu = (\rho/v_0)\,v^\mu.$$

If conventionally one assumes v^0 positive, the theory may require both signs of e/m.

Solutions with vanishing fluid density have $j^\mu = 0$ and correspond to free electromagnetic fields which may be derived from Maxwell's equations. The streaming velocity v^μ still exists[2] and, as shown by Dirac[1], may be derived from any potentials $A^{\mu *}$ which yield the desired field-strengths by gauge transformation :

$$A^\mu = A^{\mu *} + \partial^\mu S.$$

S is determined by (1), which gives explicitly,

$$\frac{\partial S}{\partial t} = \{k^2 + (\mathbf{A}^* - \operatorname{grad} S)^2\} - A^{0*}.$$

The solution involves an arbitrary function, say, the value of $S(\mathbf{x},t)$ at $t = 0$; thus the initial streaming velocity v^μ of the 'æther' is arbitrary. This freedom was not allowed by the old æther theories[3] ; for example, Neumann assumed that the velocity of the æther was in the direction of $\mathbf{H}$, and Fresnel that it was in the direction of $\mathbf{E}$.

It is of interest to determine the velocity field in simple cases.

(1) A Coulomb field :

$$E_r = Q/r^2, \qquad \mathbf{H} = 0.$$

The simplest solution is

$$A^0 = Q\left(\frac{1}{r} + |\,k/Q\,|\right), \qquad A^r = \sqrt{(A_0^2 - k^2)},$$

or

$$v^0 = 1 + \frac{1}{r}\,|\,Q/k\,|, \qquad v^r = \sqrt{(v_0^2 - 1)};$$

but the equations are not satisfied at the origin where the charge is concentrated.

(2) A free plane wave :

Consider

$$E_x = \omega a \cos\omega\,(z-t) = H_y,\ E_y = E_z = H_x = H_z = 0,$$

of which the simplest representation is

$$A_x^* = a\sin\omega\,(z-t).$$

Transformation to Dirac's gauge requires an S-function satisfying

$$(\partial S/\partial t)^2 - (a \sin \omega (z-t) - \partial S/\partial x)^2 - (\partial S/\partial y)^2 - (\partial S/\partial z)^2 = k^2.$$

Note that there are no solutions with $S = f(z-t)$, for this would make the left-hand side negative. The simplest solution is of the form

$$S = kt + f(z-t),$$

and yields

$$A_0 = k + \frac{a^2}{2k} \sin^2 \omega (z-t); \quad A_x = a \sin \omega (z-t);$$

$$A_y = 0; \quad A_z = \frac{a^2}{2k} \sin^2 \omega (z-t);$$

or a velocity field:

$$v^0 = A^0/k, \; v^1 = A_x/k, \; v^2 = 0, \; v^3 = A_z/k.$$

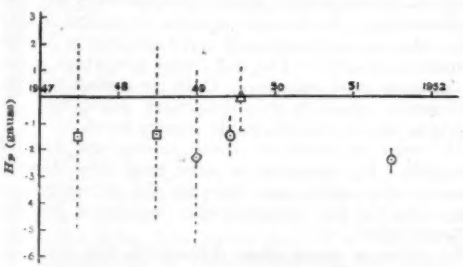
K. J. Le Couteur

Department of Theoretical Physics,
University of Liverpool.
Nov. 30.

[1] Dirac, P. A. M., *Proc. Roy. Soc.*, A, **209**, 291 (1951).
[2] Dirac, P. A. M., *Nature*, **168**, 906 (1951).
[3] Lorentz, H. A., "Lectures on Theoretical Physics", **1**, chap. 2 (Macmillan, London).

Measurements of the Sun's General Magnetic Field

Measurements of the sun's general magnetic field have been made at $\pm 45°$ heliographic latitude. The pole field-strength H_p, given in the accompanying graph, has been calculated from the observations on the assumption that the sun has a dipole field, its axis being parallel to the axis of rotation. A negative sign means that the direction of this field relative to the rotation is opposite to that for the earth.



□, Hamburg, visual[1]; ○, Hamburg, photoelectric[2];
◇, Mount Wilson, visual[3]; △, Cambridge, photographic[4]

From the visual measurements during 1947 and 1948 in Hamburg[1], it was at first roughly concluded that there was no positive field greater than 5 gauss, but a very small negative field seemed to exist. The exact values of this negative field and the photoelectric measurements for 1951 are given here. The lengths of the dotted lines represent the mean errors.

G. Thiessen

Hamburger Sternwarte,
Hamburg-Bergedorf.
Sept. 22.

[1] Thiessen, G., *Z. Astrophys.*, **26**, 130 (1949).
[2] Thiessen, G., *Observatory*, **69**, 228 (1949).
[3] Bowen, I. S., *Pub. Astro. Soc. Pacific*, **61**, 245 (1949).
[4] v. Klüber, H., *Mon. Not. Roy. Astro. Soc.*, **111**, 2 (1951).

An Improved Method for the Calculation of the Field-strength of Waves Reflected by the Ionosphere

Ten years ago a method of calculating the field-strength of the sky wave was developed by one of us[1]. Apart from the well-known conditions for ionospheric reflexion, it takes account of three independent influences: geometrical optics of the reflecting layer, absorption in the D-layer and blanketing caused by the E- and E_s-layers; in a later publication[2] considerations of refraction occurring in the reflecting layer led to a slight modification of the analysis of the first influence[3]. The influence of the blanketing E- and E_s-layers is only of interest for reflexions from the F-layer. Until now, this effect has been supposed to be a discontinuous one: a certain transmission path via the F-layer is assumed to be cut off by the E-layer, if, at the angle of transmission used, the frequency is inferior to the maximum usable frequency of the E-layer. If the frequency is greater, the ray will be assumed to pass.

This problem has now been re-examined. We must distinguish cut-off caused by the thick normal E-layer from the influence of the thin sporadic E_s-layer. In the latter case the above argument is correct, except that the angle of incidence is now calculated with a parabolic F-layer. Conditions in the F-layer affect transmission in the sense that cut-off is favoured by a low height of the F-layer (corresponding to a high value of the transmission-factor '$(M\ 3{,}000)F2$').

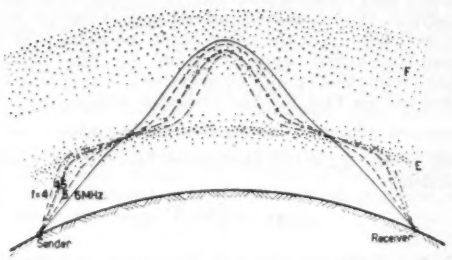


Fig. 1

In the first case, refraction occurring in the thick E-layer should not be neglected. In principle, all frequencies greater than the critical frequency of E can be propagated via the F-layer. With a given distance we find for different frequencies the rays shown in Fig. 1. For each frequency there is a new angle of departure; the lower the frequency the greater is the curvature due to refraction. But the field-strength of these curved rays is rather low, because they are attenuated by two effects: an unfavourable influence of the E-refraction on the geometrical optics of the ray, on one hand, and selective absorption occurring in the E-layer on the other. Thus the cut-off limit becomes a continuous transition with decreasing amplitude, and our problem turns out to be a problem of field-strength calculation.

In consequence the field corresponding to a transmission path near the cut-off limit must be calculated with respect to three attenuation influences: geometrical optics including refraction in the E-layer, non-selective absorption in the D-layer and selective absorption in the E-layer. The calculation of geo-

metrical optics is based on a model of two parabolic layers. We find for the distance of transmission[3]:

$$D = 2R\left\{(\alpha-\alpha_F) + \varepsilon_F.\tan\alpha_F.\left(\frac{\text{arc coth } u_F}{u_F} - 1\right) + 2\varepsilon_E.\tan\alpha_E.\left(\frac{\text{arc tanh } u_E}{u_E} - 1\right)\right\}$$

$$u_E = \sec\alpha_E \cdot \frac{f_E}{f}\ ;\ \varepsilon_E = Y_E/R_E.$$

Y_E is the half-thickness of the E-layer, R_E its radius of curvature, f_E its critical frequency, α_E the angle of an unrefracted ray measured from the vertical at the centre of the E-layer, with similar definitions for the F-layer; α is the angle of departure of the ray from the vertical; R is radius of the earth. For a given distance and frequency we first obtain from this formula the angle of departure α. Differentiating with respect to this angle, but with fixed frequency, we find $dD/d\alpha$. The decrement of 'photometric attenuation' δ_1 follows from this expression in the usual manner[2]. This is rather high for rays which are considerably curved by E-layer refraction.

The non-selective absorption is calculated as before[1] from

$$\delta_2 = \frac{B.\sec\alpha_D}{(f \pm f_L)^2};$$

f_L is the longitudinal component of the gyrofrequency, α_D the angle of incidence at the D-layer, B a constant proportional to the integral of the product of electron density and collision number. According to Booker's analysis[4], the quasi-longitudinal approximation must be used here. On the other hand, we must take the quasi-transversal approximation for the E-layer, where refraction cannot be neglected. Using Martyn's theorem, we find for the ordinary component:

$$\delta_2 = N.\cos\alpha_E.\Delta_2(\sec\alpha_E.f_E/f),$$

and, where Δ_2 is the absorption function at vertical incidence:

$$\Delta_2(q) = \int\frac{\psi f_0^2 q^2}{\mu.f_E^2}\,dy,$$

where y is the altitude, $\mu(y)$ the index of refraction, $f_0(y)$ the 'local critical frequency' in the layer, N a constant proportional to the thickness of the layer and to the collision number at its centre, $\psi(y)$ the height distribution of collisions. The function Δ_2 has recently been calculated for a parabolic layer with exponential variation of collision number[5].

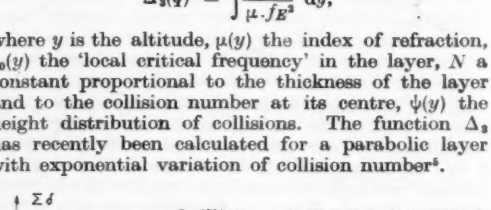


Fig. 2

The photometric attenuation δ_1 and that of selective absorption δ_2 increase more rapidly, with decreasing frequency, than the D-absorption δ_2 does. This is shown, for example, by Fig. 2. We have there as abscissa the frequency; the corresponding angle of departure is indicated by a second scale. (This angle reaches a maximum for a certain frequency; for higher frequencies it diminishes because of the increasing influence of refraction in the F-layer.)

The effective limit of blanketing is no longer a geometrical constant, but depends on the power of the transmitter and the sensitivity of the receiver. For a given case, the maximum value of the sum of the decrements is known; the lowest usable frequency with respect to cut-off follows from this. (For comparison with Fig. 2, it may be mentioned that the simple calculation in the case of a thin E_s-layer gives $f/f_E = 3{\cdot}0$ for this example.)

Numerical values for all interesting cases have been calculated and will be published as a report of this Service.

K. Bibl
K. Rawer
E. Theissen

Service de Prévision,
Ionosphérique Militaire,
Freiburg.

[1] Rawer, K., Deutsche Luftfahrtforschung FB. Nr. 1872 (1943). Later publications: *Rev. Sci.*, **85**, 361 (1947); Service Report *SPIM—R7* (1948); *Arch. Elek. Übertragung*, **5**, 154 (1951).
[2] Rawer, K., *Rev. Sci.*, **86**, 481 and 585 (1948); *Nature*, **166**, 316 (1950).
[3] Bibl, K., *Rev. Sci.*, **88**, 27 (1950).
[4] Booker, H. G., *Proc. Roy. Soc.*, A, **150**, 267 (1935).
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Discontinuous Low-frequency Delay Line with Continuously Variable Delay

Conventional low-frequency delay lines, built from capacitors and iron-cored inductors, show both linear and non-linear distortion. The linear distortion gives rise to dispersion, since the time delay depends on frequency. It is only possible to realize a time delay that is approximately constant over a limited frequency range[1-3]. The non-linear distortion is due to the iron-cored inductors. Only for signals that are sufficiently small is this distortion negligible. So the iron limits the allowable energy-level.

In some applications these limitations are not tolerable. If, moreover, a very long time delay is wanted, then either the value for the inductances or the value for the characteristic impedance becomes impracticable.

In order to avoid these difficulties, the delay circuit shown in Fig. 1 is suggested. The blocks B are buffer amplifiers with the following idealized properties: (1) amplification is unity; (2) input impedance is infinite; (3) output impedance is zero; (4) available output power is infinite.

The switches S are actuated by electrical signals. To explain the operation of the delay line, it is assumed that at a certain moment all switches are open. The voltages of the capacitors C_{n-1}, C_n, C_{n+1}, etc., are E_{n-1}, E_n, E_{n+1}, etc., respectively. Since the input impedance of the buffer amplifiers is infinite, these voltages are constant as a function of time. Now the switch S_{n+1} is closed for a short time. Then immediately the voltage of the capacitor C_{n+1} becomes E_n. If the next switch S_n is closed for a short time, the voltage of the capacitor C_n becomes E_{n-1}, and so on. So if a single switching pulse moves from the right to the left along all the switches, then all volt-

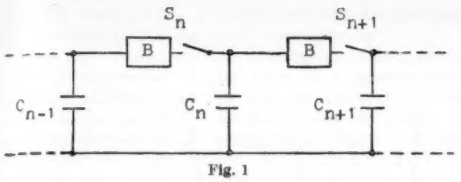

Fig. 1

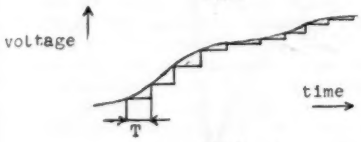

Fig. 2

ages move one step to the right. If a second pulse moves from the right to the left, all voltages move one step to the right again, and so on. This process may be continued by moving an endless train of equally spaced pulses with constant velocity from the right to the left. It can be shown that the system also behaves as a delay line if the train of pulses moves in the opposite direction. However, the most simple system is obtained when the pulses travel in neither direction, using what might be called a 'standing wave' of switching pulses instead of a travelling one. This condition can be brought about by actuating alternately all even and all odd switches. For example, all even switches may be actuated at times $t = 0, T, 2T \ldots$, and all odd switches at times $t = T/2, 3T/2, 5T/2, \ldots$ Thus, two switching signals are required with period T, shifted in time with respect to each other over an interval $T/2$. As a matter of fact, this 'standing wave' of switching pulses cannot be distinguished from a travelling train of pulses in either direction if in the latter case the distance between successive pulses is equal to twice the distance between successive switches[4].

Essentially the sections of the delay line are clamping circuits. Fig. 2 shows the voltage at the input of the first section (solid line) and the 'staircase voltage' at the output of the first section (capacitor C_1). The voltage at the output of the second section (capacitor C_2) has the same shape as that at the output of the first section, but has an extra time delay $T/2$. The delay line as a whole acts as a filter with clamping[5].

It is obvious that the time delay per section can be varied continuously by varying the period of the switching pulses. This property is especially useful when the delay line forms part of a computer for the evaluations of auto-correlation functions. If the frequency is suddenly made zero, in other words, if the switching pulses are stopped, then a certain amount of information remains stored within the line. So the circuit may be used as a memory circuit in a computer. Another possible application is the synthesis of a given transient wave-form[6].

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Effect of a Copper Surface Film on Twinning in Zinc Mono-crystals

The fact that surface oxide films increase the resistance to plastic deformation of mono-crystals of cadmium and zinc is well known from the work of Roscoe[1], Andrade[2], Harper and Cottrell[3] and others. The type of deformation which these authors observed to be affected by surface oxidation was slip along the basal planes of the mono-crystals. I have recently observed that twinning in zinc mono-crystals is also influenced by a surface film. In this case the film consists of electrodeposited copper.

The effect of an electrodeposited film on twinning was observed in three different mono-crystals of high-purity zinc. The three crystals were grown by the Bridgman method in graphite moulds. The raw material was chemically pure zinc (99·999+ per cent zinc). The crystals were triangular in shape with approximately equal sides of 0·210 in. width. They were about seven inches long. Shortly after the crystals were cleaned by dipping for 5 min. in 10 per cent hydrochloric acid, they were plated with a thin polycrystalline film of copper. The plate extended only for one-half of the length of each crystal. A Rochelle – cyanide bath was used for applying the copper, with a current of approximately 0·25 amp. passed for 60 sec. In calculating the film thickness a cathode efficiency of 60 per cent was assumed.

After 4·5-cm. gauge marks had been scratched on the sides of the specimens, they were stressed in tension by dead-weight loading. The loads were gradually increased (about 1 kgm. at a time) and the gauge marks observed. The onset of twinning could be recognized by the audible clicking noises which are characteristic of the process, movement of the gauge marks, and the appearance of bands on the surface which differed in orientation from the rest of the crystal. Prior to the deformation by twinning, no plastic deformation was observed. The critical tensile stresses required for twinning the crystals in the clean portions and in the plated portions are shown in the accompanying table.

	Mono-crystals			Bi-crystal	
	A	*B*	*C*	1	2
Orientation (deg.)					
χ	6	1	2	3	65
λ	15	16	5	6	65
θ	88	82	90	90	45
Approx. film thickness (A.)	5600	4000	3800	5000	5000
Crit. tensile stress for twinning (kgm./mm.^{2})					
Clean portion	1·05	0·81	1·43	1·06	—
Plated portion	1·45	1·61	2·35	1·36	—

χ, Angle between basal plane and tension axis; λ, angle between slip direction and tension axis; θ, angle between slip direction and normal to one surface.

The results show that an electrodeposited film of copper markedly increased the critical stress required to cause twinning in these crystals. The effect does not seem to be caused simply by the mechanical strength of the copper. The copper film would be required to support the difference in critical tensile stress between the clean and the plated portions of the crystals. This corresponds to a load of 10 kgm. or a stress in the copper of about 1,500 kgm./mm.^{2}. The tensile strength of pure copper is usually con-

sidered to be approximately 23 kgm./mm.², and the yield strength is much lower than this. Thus the effect of the copper film seems to be caused by some sort of interaction between the copper and the zinc at the surface. The dislocation theory of twinning which has recently been proposed by Cottrell and Bilby[4] is consistent with this.

The surface effect for twinning has also been observed in a rectangular zinc bi-crystal. The results for this specimen are also included in the table. However, in this case it is not clear that the film affected the twinning of one crystal because the effect observed may be attributable to inhibition of slip in the other crystal by the copper film, which indirectly affected the twinning of the first crystal. Of course, in the case of three mono-crystals, the surface effect is clearly related to twinning.

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Thermal Dependence of Elastic Constants of Electrodeposited Chromium

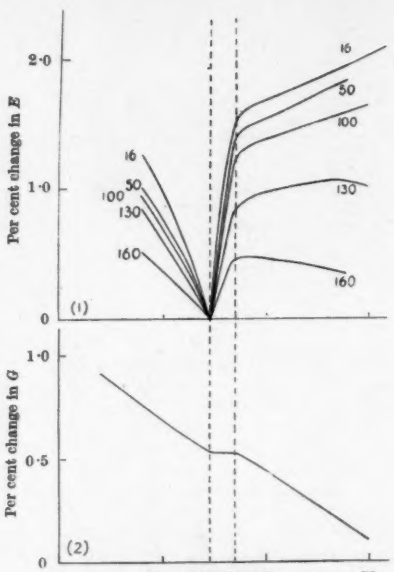
We have made a careful investigation of the transition near 37° C. in the thermal dependence of the elastic constants of electrodeposited chromium, recently reported by M. E. Fine, E. S. Greiner and W. C. Ellis[1].

Measurements of Young's modulus (E) and the modulus of rigidity (G) were made at frequencies between 15 and 160 kc./s. over the temperature-range from 10° to 80° C. on a tube, 18 cm. × 1·25 cm., of electroformed chromium, which had been annealed for 15 hr. at 544° C., by a resonance method using magnetostrictive exciters and receivers[2]. The results are shown in Figs. 1 and 2, the accuracy being such that no deviation of the measured points from the lines is observable. This was true whether the temperature was being increased or decreased.

At the lower frequencies the form of the E curves is similar to those obtained by Fine, Greiner and Ellis, who used a specimen annealed at 1,000° C. The higher annealing temperature is believed to account for the greater fluctuation which they observed. We shall be making more measurements on our specimen after further heat treatment, and the results of these will be reported in due course.

At higher frequencies, the magnitude of the fluctuation is reduced, although the temperature corresponding to minimum Young's modulus is unchanged. The transition in G shows only a short stationary portion between 36·5 and 42·5° C., the former temperature corresponding to minimum E, and the latter to the point of maximum curvature of the E curves. The transition in G is not noticeably dependent on frequency.

Bearing in mind the insensitivity to rotational strain, the results correspond to a process which



Numbers in (1) indicate frequency in kc./s.

varies the bulk modulus as a single-valued function of temperature with a time-constant of the order of 10 microsec. We do not feel in a position to form an opinion as to whether the phenomenon is characteristic of very pure chromium, as the sample used contained 1·6 per cent impurity, probably 0·6 per cent oxygen.

This forms part of the research programme at the National Physical Laboratory, and acknowledgment is made to the Director for permission to publish this account; thanks are due to Dr. Northcott of the Armament Research Establishment for the loan of the specimen.

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A New Effect Observed in Connexion with Electrically 'Exploded' Wires

If a heavy current is discharged through a very thin wire, the wire disintegrates or 'explodes' with a brilliant flash of light. Considerable noise accompanies the flash, a shock wave is emitted, and an expanding cloud of disintegration products is formed. It has been shown that exploding wires may be used for coating glass, etc.[1]. They may also serve as convenient sources of light of high intensity and short duration[2]. It was found, by means of photographic photometric reduction in four regions of the spectrum, that a copper wire of 2·5 cm. length and 0·0080 cm. diameter, exploded with 17·5 kV. peak voltage and 1·9 μfd. capacitance, gives a total emission of

$6{\cdot}5 \times 10^8$ watts/cm.^{2}. This amount can be increased with increasing voltage and capacitance.

It was now observed that, during and immediately after the explosion of the wire, a Geiger counter showed ionization near the wire of the order of 500 times the background. Within a few seconds, the ionization decreased to background count. It was then observed that, after an interval of 1·5–5 min., the ionization increased again. A second maximum of less intensity than the first one was attained. The curve of ionization passed next, within 1–3 min., through a minimum value, followed by another maximum, etc. Up to five maxima were observed extending over a time interval up to 8 min. This phenomenon showed a lower threshold value at a setting of the spark gap in series with the exploding wire of 6·4 mm.

In an attempt to explain this phenomenon the observations of Kramer[3] are recalled, who obtained ionization upon crushing of certain crystals and upon the occurrence of exothermic processes in metals. Similarly, one might expect, upon disintegration of the wire by an electric current, an ionization which would slowly decrease as a function of time. However, the combination of a high peak of ionization with fluctuations of ionization for a comparatively great length of time seems to indicate a different phenomenon due to the release, upon disintegration of the wire, of a great amount of energy in a very small area.

It seems desirable to investigate other phenomena of short duration, for example, spark discharges, etc., for after-effects which may occur after the experiment itself is 'completed'.

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Fibres of Human Sodium Deoxyribonucleate and Nucleoprotein Studied in Polarized Light by a Simple Method

In the course of studies upon deoxyribonucleic acids and nucleoproteins of human tissues, samples have been prepared by variations of the method of Mirsky and Pollister[1], and have yielded fibres suitable for study in polarized light.

Formation of nucleate or nucleoprotein fibres within sodium chloride crystals. Solutions of the nucleoprotein in *M* sodium chloride and of sodium nucleate in *M* or 2 *M* sodium chloride are evaporated slowly on glass slides. The sodium chloride crystallizes in the form of flattened pyramids, the nucleate or nucleoprotein becoming orientated as fine fibres between the horizontal laminæ of the crystal. The birefringence of these fibres can be clearly observed within the isotropic crystal when they lie at 45° to the vibration planes of the polarizer and analyser (Fig. 1); when lying parallel, extinction occurs. The sign of birefringence is found to be negative with respect to the fibre length.

Nucleoprotein fibres in methanol. The sodium chloride crystals are dissolved by methanol, the fibres remaining adherent to the glass slide. The fibres in methanol at first retain their negative birefringence; but the sign later changes to positive. Loss of birefringence occurs with long dehydration. The negative sign is restored rapidly in a moist atmosphere. Permanent preparations with either sign can be made by mounting in canada balsam. The sign of birefringence is reversible with highly purified specimens of sodium deoxyribonucleate, free from protein, as it is with the nucleoprotein.

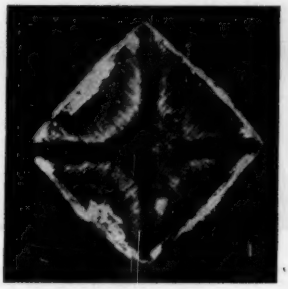

Fig. 1. Birefringence of deoxyribonucleoprotein fibres within sodium chloride crystal, at 45° position between crossed nicols. × 60

The fibres adhere to the glass slide, and no great changes of length occur with dehydration and rehydration, though the diameter alters. Astbury[2] has presented evidence from X-ray diffraction studies that the spacing of the phosphate ester linkages along the nucleic acid molecule is constant, and the negative birefringence may be due to the purine and pyrimidine rings overlying each other at 3·4-A. intervals and at right-angles to the backbone of phosphate linkages. Modifications of birefringence upon dehydration must reflect changes in orientation, perhaps with breaking of hydrogen bonds. The reversible change from negative to positive birefringence in the earlier stages of dehydration is best explained by the overlapping purine and pyrimidine plates coming to lie more in line with the backbone of phosphate ester linkages. Wilkins, Gosling and Seeds[3,4] have described an analogous situation with fibres stretched in air, and give evidence for a change in angle of 45°.

Dyeing of nucleoprotein fibres. Staining with dyes results in modification of birefringence and the appearance of anomalous colours in polarized light. Fibres

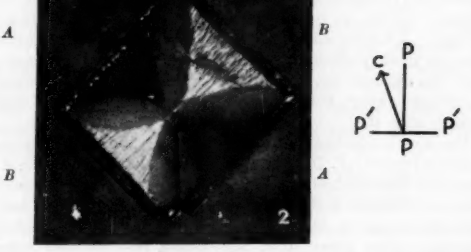

Fig. 2. Deoxyribonucleic acid fibres, stained with pyronin–methyl green, mounted in balsam. Compensator moved towards quadrants *A*—*A*; dark and red. Quadrants *B*—*B* bright and green. × 100

PP, *P′P′* vibration planes of polarizer and analyser. *C*, slow component of compensator

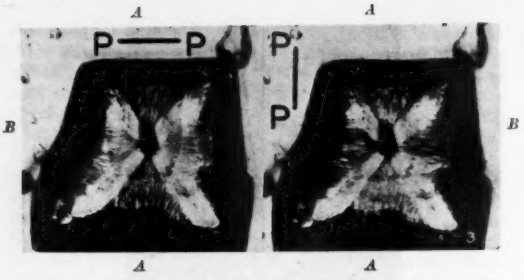

Fig. 3. Dichroism of toluidine blue-stained fibres of deoxyribonucleoprotein. *Left.* Vibration plane of polarizer ⊥ to quadrants *A*—*A*, which appear darker than *B*—*B*. *Right.* Vibration plane of polarizer ∥ to quadrants *A*—*A*, which are now lighter than *B*—*B*

stained with methyl green or pyronin possess a weak negative, green or yellow birefringence; but if the slow direction of a compensator of low retardation (stripped 35-mm. film[5]) is rotated across the vibration plane of the polarizer, a quadrant effect is observed (Fig. 2). Colour effects have been obtained with a number of basic dyes differing in structure and number of combining groups (for example, methyl violet, *C.I.* 680; toluidine blue, *C.I.* 925; lakes of hæmatoxylin and of gallocyanin, *C.I.* 883).

Measurement of the dispersion of birefringence of pyronin-dyed nucleic acid fibres has been made in conjunction with Dr. J. M. Mitchison, and suggests that the colour effects are due to anomalous dispersion. The negative birefringence of the fibres is a maximum at about 600 mμ. The $D_{max.}$ of free pyronin is at about 545 mμ.

Orientated preparations of coloured substances may exhibit positive dichroism when the electric vector of polarized light corresponds with the direction of the absorbing groups in the molecules[6]; and Preston[7] and Morton[8] have made extensive observations on the dichroism of substantively dyed cellulose fibres. Dichroism is present in the dyed nucleic acid fibres, but is more difficult to demonstrate, using a single polarizer, than anomalous colours between crossed nicols.

A comparison has been made between the dichroism and anomalous dispersion of thin needle crystals of the perchlorates[9] of pyronin and methyl green, and the fibres stained by these dyes. The weak positive dichroism and order of the anomalous colours indicate that the absorbing groups of the dye molecules lie parallel to the fibre, though the orientation is imperfect.

In the case of fibres stained with toluidine blue, however, the absorbing groups of the dye molecules appear to lie roughly at right-angles to the fibre length. Dichroism is negative (Fig. 3). The fibres also exhibit yellow, strongly negative birefringence, and the anomalous colours are dark green on moving a compensator towards the fibre, and bright red away from it.

Deoxyribonucleoprotein fibres stain with acid dyes. Aniline blue (*C.I.* 707)-stained fibres show a weak red, positive birefringence, are positively dichroic, and become bright red on compensation towards, and blue-green away from, the fibre. The dye molecules appear to be orientated alongside the nucleic acid fibre, although attached by sulphonic groups to the protein moiety, which must also lie parallel to the nucleic acid molecules[2].

A fuller account will be published in due course. We are grateful to many friends for discussion, and particularly to Prof. J. N. Davidson and to Drs. D. K. Hill, J. M. Mitchison and M. H. F. Wilkins. The photomicrographs are by Mr. E. V. Willmott.

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Effects of Electronic Irradiation on Fats

Irradiation with high-velocity electrons has recently been shown to produce changes, apparently of an oxidative nature, in the fatty components of foods[1–3], and further investigation of the phenomenon with butter-fat has revealed a number of interesting features. In the experiments we describe, samples 2–3 mm. thick were irradiated in the electron beam from a Van der Graaff generator and the ionization intensity was measured with a thin-walled ionization chamber[4]. For most of the experiments the electron energy was 1·2 MeV., and the superficial dose-rate 4×10^6 r.e.p./minute. The characteristic 'peroxide value' which developed was measured by a colorimetric method, using the oxidation of ferrous to ferric ions in the presence of thiocyanate[5].

One of the most striking effects observed has been the dependence of the apparent peroxide value on the temperature of the sample during irradiation, this value increasing considerably with decrease of temperature. Individual readings have shown a scatter of the order of ± 20 per cent; but the representative results in the accompanying table are sufficient to show that at any given temperature the 'peroxide' produced tends towards an upper limit as the dose is increased, while at room temperature, at least, it then decreases with further irradiation. Exact figures cannot be quoted for the ionic yield, owing to the tendency of the method of measurement used to over-estimate the 'peroxide value'; but, assuming a reasonable correction factor of 2 (see ref. 6), it can be seen that the ionic yields approach 1 with low doses at low temperatures, but fall away considerably at high doses. A possible explanation of these effects is that the formation of 'peroxide', or

The Dose/'Peroxide' Relationship in Butter-fat at Various Temperatures

Dose (10^6 r.e.p.)	Increase of 'peroxide value' (μmol. O_2/gm.) at stated temperatures				Approx. value expected*
	+ 37° C.	+ 20° C.	− 5° C.	c. − 70° C.	
0·5	—	1·4	—	—	3
2	1·5	2·0	7·7	9·6	12
8	—	0·8	11·4	15·2	48

* (Theoretical 'peroxide value' for ionic yield of 1) × (arbitrary correction factor of 2).

its precursor, is accompanied by a destructive process which has a high temperature coefficient.

The bleaching of the butter-fat which occurs during irradiation appears to be directly related both to the dose and to the water content of the system; but no such simple relationship holds for the reduction in keeping properties observed when the fat is stored at elevated temperatures after irradiation. This latter effect, which is shown by a decrease in the length of the induction period before normal rancidity changes develop, is probably attributable to destruction of the natural antioxidants of the butter-fat (mainly tocopherols) and can be correlated only with the 'peroxide value' produced by the radiation. This suggests indirect destruction by the 'peroxide' or some associated reactive group rather than a direct action of the radiation. The significance of this effect from the point of view of electronic sterilization of foods is that low temperatures during irradiation, with the resulting high 'peroxide values', produce a corresponding marked reduction in the keeping quality of the fats, which is in direct contrast to the beneficial effect obtained with most foods by suppressing the effects on the water present[7,8]. Addition of antioxidants before irradiation, however, offers possibilities of prolonging the subsequent storage life of the fats, and 0·02 per cent of ethyl gallate appeared to be quite effective for the purpose.

Experiments with simpler substances than butter-fat have shown that the mechanism of the initial 'peroxidation' differs from that of the normal development of oxidative rancidity. In particular, irradiation of methyl stearate, methyl oleate or methyl linoleate, all of high purity, or of a commercial sample of tristearin, all produced comparable 'peroxide values' at + 20° C. ranging from 2 to 3·5 μmol./gm. for a dose of 2 million r.e.p. The 'peroxide' in irradiated tristearin fell to about half the initial value in six days at + 50° C., behaving similarly in this respect to butter-fat to which ethyl gallate had been added before irradiation to prevent the subsequent development of rancidity. This suggests that the reactive groups in both systems are similar in regard at least to their general stability. The effect of lowering the temperature of irradiation on the 'peroxide value' produced in these simpler compounds has not yet been fully investigated; but the linoleate has shown one characteristic feature. Gelation, presumably due to polymerization, developed in samples of this substance frozen in solid carbon dioxide (c. − 70° C.) and irradiated with 2 million r.e.p.

No indication has yet been obtained of the chemical nature of the group responsible for the apparent peroxide reaction; but it has been shown that similar 'peroxide values' can be produced by irradiating at + 20° C. non-fatty substances such as pure hexane and *cyclo*hexane. Although these saturated hydrocarbons differ from the fat in giving negligible 'peroxidation' at − 70° C., part at least of the effects on the fats may be attributable to action of this type on the hydrocarbon chains. Whatever the nature of the 'peroxidation' reaction, however, it is clear that the formation during irradiation of reactive groups of this kind may be expected to produce long-term chemical effects both in foods and in biological systems.

This work has been carried out with the co-operation of the Medical Research Council as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. We are indebted to Mr. H. J. Shepherd for carrying out almost the whole of the chemical work involved.

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A Correlation between Reactivity towards Free Radicals and Free Valence Number in Polycyclic Aromatics

In recent papers dealing with theoretical molecular properties derivable on the basis of quantum mechanics, Coulson and others[1,2] stated that the free valence number calculated for a given carbon atom should be related to its ability to interact with a free radical, being a measure for the unused bonding power of that atom.

In consequence, the relative reactivities of different compounds towards a given radical should run parallel to the values of the highest free valence number ($F_{max.}$)—that is, the free valence number of the position of highest reactivity—in these molecules. Except for a few obvious cases, for example, the comparison of a simple mono-olefin and a conjugated diene, this prediction has not yet been verified experimentally. The present communication deals with such a relation, which involves the trichloromethyl radical and a variety of aromatic hydrocarbons.

In the course of detailed studies[3,4] on the retardation of the benzoyl peroxide-initiated addition of carbon tetrachloride to cetene, unsubstituted aromatics were found to act as retarders. This is probably due to addition of the chain-carrying trichloromethyl radical to the aromatic hydrocarbon, the new radical being incapable of continuing the chain reaction by abstracting a chlorine atom from carbon tetrachloride.

Thus, the relative reactivity (K_r) of several of these retarders could be determined by means of the competitive method recently employed in the quantitative comparison of alpha-methylenic reactivities[4], the overall kinetics being the same, where K_r represents the quotient

$$\frac{1}{2} \cdot \frac{\text{rate of reaction of } CCl_3' \text{ with the retarder}}{\text{rate of reaction of } CCl_3' \text{ with cetene}} .$$

However, this method requires rather low reactivity ratios of retarder and cetene, retarders more reactive than cetene leading to complete inhibition of the addition reaction. In these cases we therefore used the system bromotrichloromethane/styrene, the latter olefin being far more reactive than the former with respect to free radical addition[5].

The retardation depends upon the competitive reactions (1) and (2):

(1) $CCl_3' + \text{retarder} \xrightarrow{k_r}$ inactive radical (incapable of giving a type 3 reaction).

(2) $CCl_3' + H_2C = CH—Ph$ (styrene) $\xrightarrow{k_s}$ $CCl_3CH_2\dot{C}H—Ph$, which rapidly abstracts a bromine atom from $CBrCl_3$ to give the addition product:

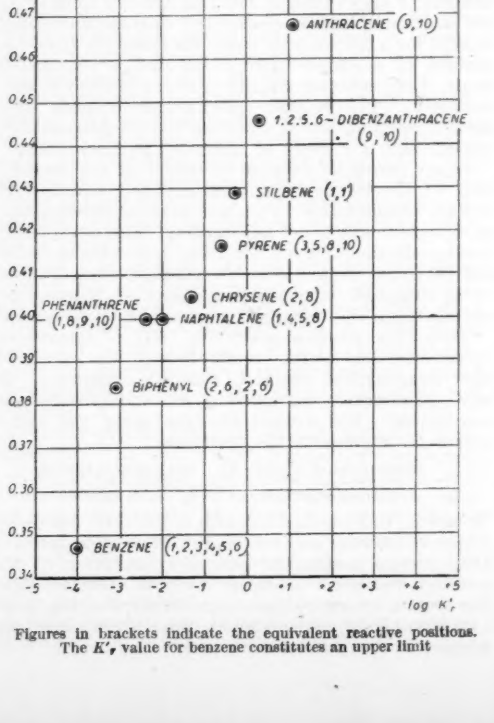
(3) $CCl_3CH_2\dot{C}H—Ph + CBrCl_3 \longrightarrow CCl_3CH_2CHBr—Ph + CCl_3'$.

On the basis of a number of plausible simplifying assumptions, one may derive the following kinetic expression:

$$K_R = (\tfrac{1}{2}k_r/k_s) = \frac{\ln\left(\frac{R_0}{R_0 - \Delta P}\right)}{\ln\left(\frac{S_0}{S_0 - A}\right)},$$

in which K_R represents the relative reactivity of the retarder, being one-half the ratio of the reaction-rates of (1) and (2), respectively; ΔP is the amount of benzoyl peroxide decomposed in the course of the experiment, R_0 and S_0 are the intakes of retarder and of styrene, respectively, and A is the amount of bromotrichloromethane bound to styrene; all quantities being expressed in millimoles. Excess halide was employed in all experiments ($3\frac{1}{2}$: 1 on a molar basis); the temperature was 91° C., both in the experiments with carbon tetrachloride/cetene and in the experiments with bromotrichloromethane/styrene.

The results were in satisfactory agreement with the above equation. From retardation experiments involving the same retarder in the two methods, one unit on the styrene scale appeared to correspond with about twenty-five units on the cetene scale.



Figures in brackets indicate the equivalent reactive positions. The K'_r value for benzene constitutes an upper limit

The accompanying graph shows a plot of $F_{max.}$ for each molecule as calculated by means of the molecular orbital method[6] against the logarithms of the experimental relative reactivities. The latter values (K_r') have been expressed according to the cetene scale, K_R values having been multiplied by 25; in those cases where two or more positions in the molecule have the same free valence number, the reactivity values have been divided by the number of equivalent positions. In doing this, possible contributions to K_r' from positions with lower F values have been neglected; generally, these F values are much lower than $F_{max.}$ The correlation between the two quantities is seen to be even better than could have been anticipated in view of the approximations involved in the calculations. The free valence numbers for 3,4-benzpyrene have not yet been calculated by the molecular orbital method; from the reactivity found ($K_R = 2{\cdot}8$), $\log K_r'$ is found to be 1·85, which should correspond with a free valence number of about 0·49 for the reactive 5-position in this molecule. The values for stilbene, which is the only substituted aromatic investigated, seem to fit the other results quite well.

A similar relationship, though showing some striking discrepancies, holds when $\log K_r'$ is plotted against $F_{max.}$ calculated by other methods[6c]. The limited number of data as regards the changes in unsaturation energy upon the addition of a free radical calculated by the molecular orbital method, which were recently reported by Burkitt, Coulson and Longuet-Higgins[1], are completely in agreement with $\log K_r'$.

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Splitting of N-phthalyl Groups of Amino-acids with Phenylhydrazine

Among removable groups employed for protecting the amino group of amino-acids and peptides, the phthalyl group has the advantage of giving stable and easily crystallizable derivatives[1–5]. Splitting of such N-phthalyl groups is usually accomplished by refluxing with alcoholic hydrazine hydroxide, followed by heating with dilute aqueous acid[2–5].

We have found that this splitting is more conveniently accomplished by refluxing for two hours the N-phthalyl amino-acid or peptide with 1·5–2 equivalents of phenylhydrazine and 1 equivalent of

N-tri-*n*-butylamine in 96 per cent ethyl alcohol. After addition of 1·5 volume of methylethylketone and of 1 equivalent of glacial acetic acid, the pure free amino-acid or peptide crystallizes on cooling in a high yield.

The procedure has so far been successfully applied to N-phthalyl-glycine, N-phthalyl-leucine, N-phthalyl-glycyl-glycine, N-phthalyl-glycyl-phenylalanine, and N-phthalyl-glycyl-leucyl-glycyl-glycine. From the solution, N-phenyl-N′-N′-phthalylhydrazine[6] can be isolated. This new method has the following advantages over the usual splitting with hydrazine hydroxide: splitting is effected in only one step, heating in acidic media is avoided, free amino-acids or peptides are obtained directly, and phenylhydrazine is more convenient to handle than hydrazine hydroxide.

Already in 1913, Scheiber[7] made the casual observation that phthalyl-glycine is split by phenylhydrazine in dilute aqueous acidic media; but this observation has since been overlooked by subsequent authors working on the subject.

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Production of Sulphur Trioxide during the Combustion of Carbon in Air Containing Small Quantities of Sulphur Dioxide

Recent studies[1–4] of the combustion of carbon at elevated temperatures have done much to elucidate the mechanism of reaction. The work of Arthur and Bowring on the combustion of various carbons in oxidizing gases containing inhibitors, mainly volatile chlorine compounds, has established the major role of the gas-phase oxidation of carbon monoxide in determining the partition of the energy release between solid and gas. Sulphur trioxide was found to be a relatively weak inhibitor of carbon monoxide combustion at 850° C.; but the effect of sulphur dioxide was not examined in detail. It is known that oxidation of sulphur dioxide occurs in the pre-flame[5] and flame combustion[6] of carbon monoxide, and it seemed desirable to extend this work to the carbon–oxygen system where, at temperatures above about 650°, carbon monoxide combustion takes place in close proximity to a carbon surface.

Carbon tubes, of 1·0 cm. internal diameter and of varying length, were fitted tightly into an electrically heated quartz tube, 2·0 cm. in diameter, and burned in a stream of air (750 c.c./min.) containing 0·08 per cent by volume of sulphur dioxide. The air was dried by passage through magnesium perchlorate and phosphorus pentoxide; the electrode carbon used had the analysis: C, 99·6; H, 0·1; ash, <0·5; moisture, 0·09 per cent (accurate determination of hydrogen and ash contents was difficult). The dew-point technique[7] was used to indicate the amount of sulphur trioxide present in the exit gases.

In order to establish the temperature-range over which sulphur trioxide is produced, a carbon tube

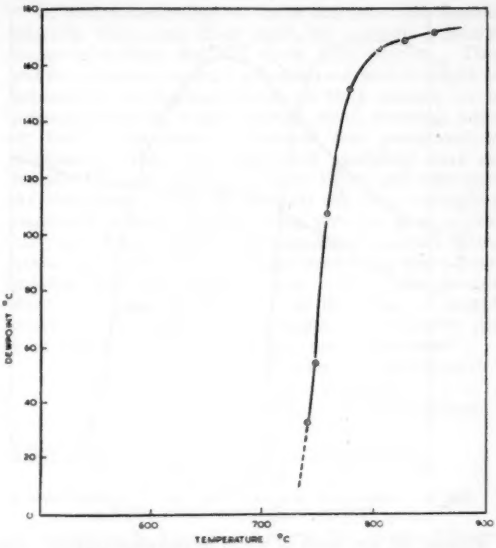

Fig. 1. Variation of dew-point with temperature (carbon tube 1 cm. long; rate of heating, 10° C./min.)

1 cm. in length was placed in the quartz tube at 500° C. and the temperature raised at the rate of 10° C. a minute. As Fig. 1 indicates, the dew-point of the gas, and hence the sulphur trioxide content, increased very rapidly over the temperature range 730–780°, and this coincided with the appearance of a blue glow, which increased in intensity with temperature. This luminescence has been commented on by various workers[2,8] and is known[9] to give the flame spectrum of carbon monoxide.

When carbon tubes of varying lengths were employed at 900° C., the relation between dew-point and time was of the form shown in Fig. 2. With a tube 1 cm. in length the dew-point showed a slight initial increase, and then remained at a high value until about 80 per cent of the carbon had been consumed. Thereafter the dew-point decreased very rapidly, due usually to the disintegration of the carbon residue. With longer tubes, much lower dew-points were measured at the start of a run, but these gradually increased as the carbon burnt away and eventually the behaviour was the same as with a 1-cm. tube.

These results find a ready explanation in the 'two-stage' mechanism of oxygen consumption in the combustion of carbonaceous fuels advanced by Bangham and co-workers[1]. At temperatures above about 600°, carbon monoxide is the major product of the primary solid–gas reaction, and this then burns in the gas phase to carbon dioxide. These two processes lead to a rapid depletion of oxygen and, for a given rate of flow of air, there exists a critical path-length beyond which there is little or no free oxygen in the gases. In the long tubes the sulphur trioxide produced during the combustion of carbon monoxide in the first part of the tube can therefore undergo reduction at the surface of the remaining carbon:

$$C_{solid} + SO_3 = CO + SO_2 + 4 \text{ k.cal.}$$

The results of Crossley, Poll and Sweett[10] show that this reaction is likely to be extremely rapid at temperatures of the order of 800–900° C. It would also

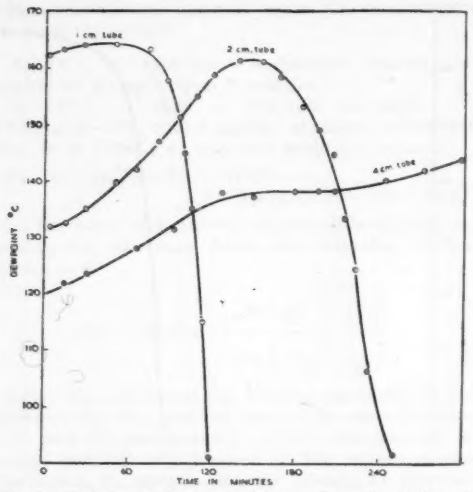

Fig. 2. Variation of dew-point with time for carbon tubes of different lengths (temperature, 900° C.)

appear, on the basis of these initial experiments, that observations on the extent of formation of sulphur trioxide in the above system, where the hydrogen or moisture content both of the solid and of the gas can be made extremely low, might possibly be of value in elucidating the mechanism of combustion of dry carbon monoxide – oxygen mixtures.

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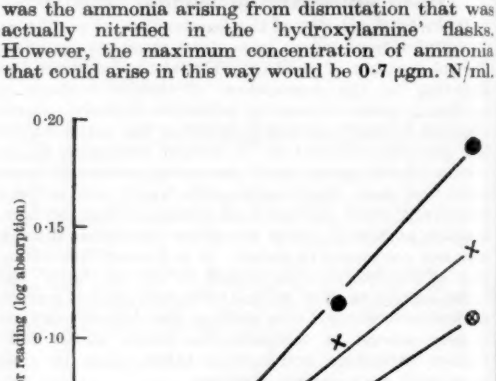
Hydroxylamine as an Intermediate in Nitrification

Ammonia is oxidized to nitrite by micro-organisms of the *Nitrosomonas* group. Many attempts have been made to identify the intermediate compounds in this oxidation; but none has so far been successful. It has been suggested[1] that one intermediate might be hydroxylamine, and there is indirect evidence[2] that hydroxylamine is formed during nitrification in soil. On the other hand, it is not nitrified in soil[3], even in concentrations as low as 7 μgm. N/ml., nor is it nitrified at a concentration of 28 μgm. N/ml. in culture[4]. Experiments carried out on washed suspensions of *Nitrosomonas* in this laboratory have now shown that while hydroxylamine is toxic to the nitrification of ammonia, and is not itself nitrified at concentrations in excess of a few micrograms nitrogen per millilitre, yet at concentrations below about 1·5 μgm. N/ml. it is nitrified as rapidly as ammonia and is thus a possible intermediate in the nitrification process.

Nitrosomonas was cultured by a technique similar to that already described[5]. When nitrification was well established in the culture, approximately 50 ml. of the culture was centrifuged to separate the calcium carbonate precipitate to which the organisms adhere. This precipitate, with its adherent organisms, was washed five times at the centrifuge with 50-ml. lots of 0·7 per cent sodium chloride and suspended in distilled water. Portions of this washed suspension, which had a *p*H of about 8·4, were incubated at 30° C. with hydroxylamine hydrochloride or ammonium sulphate at the appropriate concentrations in 500-ml. flasks. The total volume of fluid incubated was 20 ml., and since this volume formed only a thin layer over the bottom of the flask, the organisms were assured of an adequate supply of oxygen. Every thirty minutes the contents of the flasks were swirled to resuspend any calcium carbonate that might have sunk to the bottom and a 5-ml. sample of the contents was withdrawn. This was diluted with 20 ml. water, centrifuged to remove the calcium carbonate, and the supernatant liquid treated with Greiss Ilosva reagent. The resulting red colour, which is proportional to the amount of nitrite-nitrogen present, was read in a Biochem Absorptiometer fitted with a 4-cm. cell and a green filter. The blank solution for a colorimetric estimation was from a flask set up in the same way as the experimental flask except that a boiled inoculum was used.

The mean results from two typical experiments are shown in the accompanying graph. It will be seen that at a concentration of 1·4 μgm. N/ml. the rate of formation of nitrite from hydroxylamine hydrochloride was at least as great, or greater, than its rate of formation from ammonium sulphate at the same concentration of nitrogen. It might be argued that the hydroxylamine was first dismuted into ammonia and nitrous oxide or nitrogen, and that it was the ammonia arising from dismutation that was actually nitrified in the 'hydroxylamine' flasks. However, the maximum concentration of ammonia that could arise in this way would be 0·7 μgm. N/ml.



Nitrification of hydroxylamine and ammonia. Solid circles: hydroxylamine hydrochloride, 1·4 μgm. N/ml. Crosses: ammonium sulphate, 1·4 μgm. N/ml. Crossed circles: ammonium sulphate, 0·7 μgm. N/ml.

under the experimental conditions. As the graph shows, this concentration of ammonia was nitrified far more slowly than the hydroxylamine.

The results suggest that under suitable conditions hydroxylamine can be nitrified when added extracellularly. Preliminary results from experiments now in hand indicate that, at *p*H's lower than 8·4, hydroxylamine is nitrified a good deal more rapidly than ammonia. It therefore seems probable that hydroxylamine is an intermediate compound in the nitrification of ammonia.

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Effects of Intraventricular Acetylcholine, Cholinesterase, and Related Compounds in Normal and 'Catatonic' Cats

IT has been known for some time that di-*iso*-fluorophosphonate and similar drugs, which are anticholinesterases in nature, in toxic doses produce syndromes resembling certain psychoses, and that in schizophrenics they aggravate signs and symptoms[1]. Conversely, it was thought that cholinesterase and other drugs counteracting acetylcholine should reduce the manifestations of schizophrenia, and they have done so, on injection into the cerebral ventricles of man[2].

Intraventricular injections of acetylcholine and of some of its antagonists were studied for their effect on the electroencephalogram of cats paralysed by erythroidine, or on the isolated cat brain. The former produces recruitment[3,4], the latter attenuates this response.

Eserine aggravates Parkinsonism in Parkinsonian man and in monkeys with lesions between the nucleus ruber and substantia nigra, whereas atropine, hyoscine and similar compounds decrease symptoms. Cannon and Rosenblueth's thesis[5] that in the peripheral nervous system the deafferented part becomes oversensitized to stimuli may obtain also for the central nervous system—as was suggested originally by Dale[6] and by Lettvin[7] in the case of Parkinsonism.

Six cats were subjected to lesions by means of a stereotaxic instrument and electrolysis at a site originally described by Ingram and Ranson[8] and later by Bailey[9]. By slightly modifying this lesion, a syndrome was produced that is indistinguishable from human catatonia; smaller lesions (two cats) permitted recovery within ten days to the extent of normal feeding and drinking and response to stimuli from man and other cats; larger lesions were not attended by any significant recovery within ten days. In the first group, intraventricular injection of acetylcholine caused a return or exaggeration of all 'catatonic' signs for two hours. In the second group, partially purified cholinesterase (with an activity of 2 *p*H units per hour per millilitre as assayed by Michel[10]), prepared for us from human erythrocytes by Dr. James Bain, produced a transient remission (1½–2 hr.) of the disability, and on repeated injections improvement was sustained and advanced.

In contradistinction to these animals with lesions, animals with none (four cats), on a single injection of acetylcholine, did not show this picture. They exhibited agitation and a behaviour which might be interpreted as hallucinatory, or they seemed to be preoccupied with their internal state, showing anger or fear in response to stimuli not perceived by observers; they also salivated profusely and defæcated within a few minutes after the injection. As the effect of the drug wore off, they resembled markedly a man who has been given a dose of pilocarpine. They became approximately normal within about one hour. Mecholyl and carbachol had a more marked and prolonged action. The doses ranged from 0·5 mgm. to 2 mgm. in the case of acetylcholine, 3·75 mgm. to 7·5 mgm. of mecholyl and 0·05 mgm. to 0·1 mgm. in the case of carbachol.

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Human Plasma as Antigen in the Preparation of Precipitin Serum

HUMAN serum is generally used as an antigen for the preparation of anti-human serum in precipitin tests. The use of human plasma does not seem to have had sufficient trials for this purpose. Johnson and Rawson[1] concluded that plasma of some wild animals was unsatisfactory in the preparation of precipitin serum. We have not found any reference to human plasma being used as antigen in the literature available to us.

Precipitin sera have been prepared in the Malaria Institute of India during the past thirteen years as a routine for the determination of the sources of mosquito blood meals. Since 1948, human plasma has been successfully used as an antigen. Twenty-five rabbits and twenty-nine fowls were immunized with citrated human plasma, following the conventional methods of the single- and multiple-dose techniques; ten rabbits and five fowls yielded specific anti-sera varying in titre from 1 in 1,000 to 1 in 5,000.

The significance of these is that antigen in the form of plasma is more easily and readily available from blood banks than serum obtained from volunteers and patients in hospitals.

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Inflorescence Development in *Lolium* during the Arctic Summer

During a recent study of the effect of temperature and photoperiod on spikelet initiation in *Lolium*[1], continuous artificial light supplied by 'daylight' fluorescent lamps was used for examining 'ripeness-to-flower' of the shoot apex. If an apex is 'ripe-to-flower', that is, competent to respond to the photoperiodic stimulus, spikelet development begins at once on exposure to continuous light. In some species, such as the Mediterranean annuals *L. temulentum*, *L. remotum* and *L. gaudini*, the shoot apex is competent immediately after germination; in others, such as *L. italicum* and most plants of *L. rigidum*, the apex eventually becomes competent, but this process is accelerated by low temperature; and in most strains of *L. perenne* competence is never attained in the absence of low temperature.

presence of three leaf primordia on the shoot apex in the embryo, and production of new leaf primordia on the apex usually continues until spikelet buds are formed. This suggests that, under Arctic conditions, differentiation of spikelet buds occurred very soon after germination. Ear emergence, however, was no earlier than under artificial continuous light, suggesting that although spikelet initiation may be accelerated in the Arctic summer, subsequent elongation of the inflorescence is retarded.

Previous work[1] has shown that 'daylight' fluorescent lamps and natural daylight at Aberystwyth have similar photoperiodic effects under the same temperature conditions. Differing responses to Arctic summer daylight and artificial continuous light may thus be an effect of temperature. Transplant work with *L. perenne*, to be reported later, has shown accumulated temperature to be a useful measure of the effect of temperature on rate of inflorescence

		Lolium temulentum L. ex Bordeaux	*Lolium remotum* Schrank. ex Malta	*Lolium gaudini* Parl. ex Israel	Temperatures
Børselv, Finmark. (70° 20′ N.) Continuous natural daylight	Germination—ear emergence (days)	39·64 ± 0·49	40·04 ± 0·35	45·00 ± 0·63	Mean max. 69·5° F. Mean min. 42·3° F.
	Leaf No.	4·00 ± 0·00	3·20 ± 0·08	4·14 ± 0·10	Accumulated temp. 556 day-degrees
Aberystwyth. (52° 25′ N.) Continuous artificial light, indoors	Germination—ear emergence (days)	36·00 ± 0·33	29·11 ± 0·47	28·00 ± 0·57	Mean max. 59·6° F. Mean min. 55·4° F.
	Leaf No.	6·10 ± 0·10	5·00 ± 0·00	5·32 ± 0·11	Accumulated temp. 620 day-degrees
Aberystwyth. (52° 25′ N.) Heated greenhouse, natural day-length	Germination—ear emergence (days)	54·82 ± 0·30	61·38 ± 0·53	—	Mean max. 71·3° F. Mean min. 46·8° F.
	Leaf No.	8·00 ± 0·00	8·75 ± 0·16	—	Accumulated temp. 682 day-degrees

Each lot contained initially 20 seedlings.

The Cambridge expedition to Finmark in the summer of 1950 gave an opportunity for comparing the effects of continuous artificial light and of the continuous natural daylight of the Arctic summer. As only the photoperiodic effects were to be compared, species of *Lolium* were employed which respond to photoperiod very soon after germination. Three Mediterranean annual species were sown (by A. F. M.-K.) at Børselv, Finmark (70° 20′ N.), on July 7, 1950, and received continuous natural daylight until ear emergence between August 20 and 30. The same species were grown indoors under continuous artificial light at Aberystwyth, and two of the species were sown on March 18 in a heated greenhouse and exposed to natural day-lengths at Aberystwyth (13 hr. 12 min. on March 18 – 17 hr. 30 min. on May 20 at date of ear emergence).

For each treatment the time from germination to ear emergence and the leaf number before heading were recorded. Daily air maximum and minimum temperatures were taken, and the accumulated temperature, in day degrees above 42° F., calculated for the forty days after germination. Details of species sown and experimental results are given in the accompanying table.

The time from germination to ear emergence was of the same order in both artificial and natural continuous light; but ear emergence was significantly later under Arctic conditions. In all species, however, Arctic conditions resulted in a lower leaf number before heading. In *L. remotum*, many plants headed after only three leaves, a leaf number lower than any previously obtained in *Lolium*. Dissection shows the development. In the present case, accumulated temperatures are similar for both treatments; but an inspection of the mean maxima and minima shows considerable daily fluctuation in the Arctic, with three minima below 32° F. In the artificial light, an even temperature of 55–60° F. was maintained.

In the seedlings exposed to natural day-length at Aberystwyth, time from germination to ear emergence and leaf number before heading were both greater than in the continuous-light treatments, although the photoperiod (13 hr. 12 min.) on the sowing date was above the critical. Dissection showed spikelet initiation to be slower during the shorter photoperiods of March and April than in continuous illumination at similar temperatures. Subsequent elongation of the inflorescence was, however, equally rapid under both treatments.

These results suggest that spikelet initiation and subsequent elongation of the inflorescence may show different responses to both temperature and photoperiod.

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[1] Cooper, J. P., *J. Ecol.* (in the press).

Rust Resistance in Linseed

INVESTIGATIONS on physiological specialization in *Melampsora lini* (Pers.) Lév. and the genetics of resistance of *Linum usitatissimum* L. have been going on in the University of Sydney since 1940 [1-3].

The physiological race survey covering all the Australian States has been curtailed recently, while the differential series is being 'pure lined'; but fifteen races have been identified to date using Flor's original set of differential varieties and two additional Argentine varieties. A race attacking 'Ottawa 770 *B*' appeared in Western Australia in 1949, and eliminates this variety as a promising immune parent.

Several races have been used in the genetical studies. Australian race *K* has given results closely paralleling those described by Flor[4] in the United States. 'Newland', 'Ottawa 770 *B*', 'Bombay', 'J.W.S.', 'Tammes Pale Blue' and 'Abyssinian' are unifactorial, and 'Bolley Golden' is bifactorial, for resistance to this race. The factors fall into the allelic series postulated for them by Flor.

Australian race *A* has given different results. 'Bison', susceptible to all the races determined by Flor, carries a single dominant factor for resistance, probably falling in Flor's *L* series. 'Ottawa 770 *B*' and 'Newland' each carry one factor (apparently in the *N* series) additional to those determined in the United States. The additional 'Ottawa' factor also operates against race *E*.

Uredospore germination is being intensively studied, and it has been found possible to obtain a more rapid and often a greater percentage germination of uredospores, stored at 3·5° C. for varying periods, by floating them on an aqueous seedling linseed extract. Consistently high percentage germinations (up to 80 per cent) have been given with spores of most races stored for eight months, and moderate germinations have been obtained up to fourteen months: in one case 25 per cent germination was obtained after seventeen months. A comprehensive study of germination in relation to cold storage is now being undertaken, using several races of rust.

Twisted and variously shaped rings of coloured bell wire have been used to advantage in labelling plants showing different characters. The wire is available in at least six different colours, is very easily shaped, wears well, and is fairly cheap.

An excised shoot technique has been developed to facilitate the work. By this method shoots of linseed are excised above the cotyledons, placed in tap water or nutrient solution, and inoculated at once with uredospores. Normal rust reactions are obtained. Unless heavily infected, such shoots soon develop a root system, and may then be transplanted or left *in situ* to set seed. The efficiency of this technique is enhanced by the prolific branching of cut-back seedlings.

A number of advantages follow; for example, rapid clonal increase of valuable plants, testing of one plant with several races of rust simultaneously by forcing it to shoot from the base and excising the new shoots, standardization of plant nutrient medium, testing of one plant with an almost unlimited number of races, reduction in bench-space requirements, and so on.

Full details of the work will be published shortly.

H. B. KERR
Faculty of Agriculture, University of Sydney,
Sydney. Aug. 29.

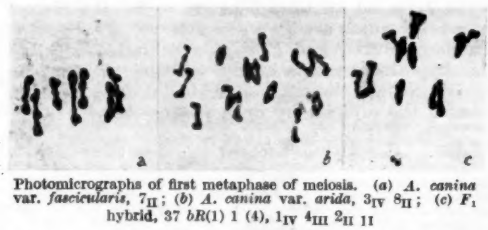
[1] Waterhouse, W. L., and Watson, I. A., *Roy. Soc. N.S.W. J. and Proc.*, **75**, 115 (1941); **77**, 138 (1943).
[2] Baker, E. P. (unpublished work).
[3] Charles, A. W. (unpublished honours thesis).
[4] Flor, H. H., *J. Agric. Res.*, **74**, 241 (1947).

Autotetraploidy in *Agrostis canina*

IN his revision of the British species of *Agrostis*, Philipson[1] subdivided *Agrostis canina* into the two varieties *A. canina* var. *fascicularis* and *A. canina* var. *arida*. These two varieties differ from one another in several morphological features, which are mainly of a quantitative nature; but the basis of separation in Philipson's key is the presence of stolons in var. *fascicularis* and of rhizomes in var. *arida*. These varieties can be separated also by their ecological preferences. Var. *fascicularis* is commonly found on wet acid soils, and var. *arida* on the drier acid soils. Both varieties may, however, occur together.

Two chromosome numbers have been reported for *Agrostis canina*, namely, $2n = 14$ (Sokolovskaya)[2] and $2n = 28$ (Wulff)[3]. These numbers, however, were not associated with the two varietal types. More recently, Björkman[4] has reported $2n = 14$ for var. *fascicularis*, and $2n = 28$ for var. *arida*.

The plants used by my colleague, Mr. W. Ellis Davies, for producing F_1 hybrids between the two varieties were also found to have the same numbers, and through his kindness I was able to examine the actual parents and their hybrids at meiosis.



Photomicrographs of first metaphase of meiosis. (*a*) *A. canina* var. *fascicularis*, 7_{II}; (*b*) *A. canina* var. *arida*, 3_{IV} 8_{II}; (*c*) F_1 hybrid, 37 *bR*(1) 1 (4), 1_{IV} 4_{III} 2_{II} 1I

The relevant data from these cytological investigations are contained in the accompanying table:

Plant	Chromosome number	Av. chiasma freq. per chromosome	Average MI configuration per pollen mother cell				No. of cells
			I	II	III	IV	
A. canina var. *fascicularis* (*Brc* 343 (14))	14	0·64	0·11	6·94	—	—	106
A. canina var. *arida* (*Brc* 314 (19))	28	0·71	0·34	10·12	0·15	1·73	72
F_1 hybrids:							
37 *bR* (1) 1 (4)	21	0·68	2·17	2·20	4·77	0·02	36
37 *bR* (1) 2 (3)	21	0·67	2·85	2·85	4·14	—	49
37 *bR* (1) 13 (4)	21	0·70	2·10	2·13	4·83	0·03	30

Whereas var. *fascicularis* behaves as a typical diploid, var. *arida* is characterized by the presence of 0–5 quadrivalents per pollen mother cell. As many as 13 per cent of the cells have four or five quadrivalents, indicating the potentiality for chromosome pairing in this variety. Thus we may consider that var. *arida* is probably an autotetraploid. The high average number of 4·0 quadrivalents per

pollen mother cell found by Björkman in his material supports this conclusion.

The F_1 hybrids have from 0–7 trivalents per pollen mother cell, with an average of 4·58 for the three plants investigated. This average figure compares favourably with that obtained by Myers[5] for autotriploid *Lolium perenne*. It is concluded, then, that the three genoms present in the hybrids are highly homologous.

Björkman has suggested that var. *arida* and var. *fascicularis* have similar origins. However, from the present study we may go even further and suggest that *A. canina* var. *arida* is the autotetraploid form of *A. canina* var. *fascicularis*. Morphology is not in disagreement with this suggestion.

Further work on the cytology of *Agrostis* is being continued, and the genus is being studied from the points of view of taxonomy, ecology and breeding by W. Ellis Davies and A. Lazenby, Welsh Plant Breeding Station, and A. D. Bradshaw, University College of North Wales, Bangor.

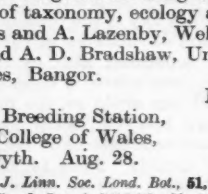
Keith Jones

Welsh Plant Breeding Station,
University College of Wales,
Aberystwyth. Aug. 28.

[1] Philipson, W. R., *J. Linn. Soc. Lond. Bot.*, **51**, 73 (1937).
[2] Sokolovskaya, A. P., *J. Bot. de l'URSS.*, **22**, 478 (1937); *Cytologia*, **8**, 452 (1938).
[3] Wulff, H. D., *Ber. d. deut. Bot. Ges.*, **55**, 262 (1937).
[4] Björkman, S. O., *Hereditas*, **37**, 465 (1951).
[5] Myers, W. M., *J. Hered.*, **35**, 17 (1944).

Origin of *Poa annua* L.

It has been suggested by Nannfeldt[1] that *Poa annua* L. is an allotetraploid ($2n = 28$) the diploid parents of which are *P. infirma* H. B. K. (*P. exilis* (Thomm.) Murb.) and *P. supina* Schrad. ($2n = 14$). This hypothesis seems highly probable on morphological grounds, though Nannfeldt did not succeed in crossing the diploids by open pollinations.



Meiosis in *Poa annua* × *infirma*, showing 7 bivalents and 7 univalents. Aceto-carmine squash. Drawing traced from two photographs taken at different levels. × 1,500

In 1950 an attempt was made to pollinate *P. annua* with pollen from *P. infirma*. About sixty florets were emasculated on two plants of *P. annua* and the remaining spikelets removed. The plants were covered and pollinated daily for a fortnight with pollen of *P. infirma*. Four seeds resulted, one of which germinated and produced a hybrid which is intermediate in character between the parents and completely sterile, the anthers failing to dehisce. This plant has $2n = 21$, as is to be expected, and at meiosis always shows 7 bivalents and 7 univalents (see diagram). The chromosome set of *P. infirma* must therefore be homologous with one of the *P. annua* sets, conditions which could only occur if *P. infirma* were, in fact, one of the parents of the allotetraploid. The apparently perfect pairing of the bivalents in the hybrid strongly suggests that *P. annua* is a plant of comparatively recent origin. Attempts are being made to complete the proof of Nannfeldt's hypothesis.

My thanks are due to Mr. M. Borrill for assistance with the difficult work of hybridizing. A full account of the work will be published in *Watsonia*.

T. G. Tutin

Department of Botany,
University College,
Leicester.
Aug. 30.

[1] Nannfeldt, J. A., *Botaniska Notiser*, 238 (1937).

Polychætes New to British Waters

In a survey of the sub-littoral fauna of the Firth of Clyde carried out in 1949 and 1950, a large number of Polychæta were found which had not previously been recorded from the area. Of these, ten species appear to be new to Britain, although all but two are known from neighbouring continental waters and are likely to occur off the south and west coasts of Britain. The new records are:

Aphroditidæ:	*Leanira yhleni* Malmgren
	Leanira tetragona Oersted
Phyllodocidæ:	*Phyllodoce mucosa* Oersted
	Eulalia fucescens St. Joseph
Glyceridæ:	*Goniada norvegica* Oersted
Cirratulidæ:	*Tharyx multibranchiis* (Grube)
Capitellidæ:	*Dasybranchus caducus* Grube
Ampharetidæ:	*Amage adspersa* (Grube)
	Amage gullarii Marion

Good descriptions of these are given by Fauvel[1]. The two species of *Amage* have not hitherto been recorded outside the Mediterranean, and indeed the genus is new to Britain. In addition, two species have been found which do not accord with any known description and have therefore been described[2]. They are *Spiochætopterus* sp. (Chætopteridæ) and *Amage scotica* (Ampharetidæ).

A full account of the new records for the Clyde Sea Area and descriptions of the new species is being published elsewhere.

R. B. Clark

Department of Zoology,
University, Glasgow,
and
Marine Station,
Millport.
Sept. 6.

[1] Fauvel, P., "Polychètes errantes" (Faune de France, **5**) (1923); "Polychètes sedentaires" (Faune de France, **16**) (1927).
[2] Clark, R. B. (in the press).

Chairs of Chemistry in Great Britain

In the book, "An Eighteenth Century Lectureship in Chemistry", published in 1950, the statement is made that the regius chair of chemistry founded in the University of Glasgow in 1818 is "the earliest Chair of chemistry, *tout simple*, in the country"; and the statement is also quoted in the review of the book in *Nature* of December 8, 1951. This statement must not be allowed to pass unchallenged. As I have pointed out in "The Teaching of Chemistry in the Universities of Aberdeen" (1935), a chair of chemistry was founded in Marischal College and University, Aberdeen, in 1793, the first occupant of the chair being a Dr. George French. This chair, therefore, must take rank as the earliest chair of chemistry in Great Britain.

Alex. Findlay

66 Manor Way,
Beckenham,
Kent. Jan. 5.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 28

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Should Further Television Development be Concentrated on Colour to the Exclusion of Black and White?" (to be opened by Mr. L. C. Jesty).

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Erik Jacobsen: "The Metabolism of Ethyl Alcohol".*

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.15 p.m.—Sir John Russell, F.R.S.: "India, Pakistan and Ceylon, 1, Population and Food in South Asia".* (Further Lectures on February 4, 18, 25, March 3, 17, 24 and 31.)

SOUTH-EAST LONDON TECHNICAL COLLEGE (at Lewisham Way, Lewisham, London, S.E.4), at 7 p.m.—Mr. J. C. Dawkins: "Production and Use of Diamond Grinding Wheels".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the ALEMBIC CLUB, in the Physical Chemistry Laboratory, The University, Oxford), at 8.15 p.m.—Dr. E. J. Bowen, F.R.S.: "Fluorescence Quenching".

Tuesday, January 29

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with UNIVERSITY COLLEGE CHEMICAL AND PHYSICAL SOCIETY, in the Large Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Sir Eric Rideal, F.R.S.: "Catalytic Hydrogenation".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. P. A. Sheppard: "Physical Methods in Meteorology". (Further Lectures on February 5, 12 and 19.)

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. C. H. Bartlett: "Spain".

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Prof. A. Tustin: "Some Mechanical Considerations in the Design of Electrical Servo Systems".

Wednesday, January 30

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. Geoffrey Arthur Kellaway and Prof. James Haward Taylor: "Early Stages in the Physiographic Evolution of a portion of the East Midlands".

ROYAL STATISTICAL SOCIETY, BIRMINGHAM GROUP (in the Chamber of Commerce, 95 New Street, Birmingham), at 6.45 p.m.—Mr. M. G. Peakman: "Problems of Quality Control in a Rubber Factory".

Thursday, January 31

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Prof. R. W. Ditchburn and Mr. G. A. J. Orchard: "Polarization of Totally-reflected Light"; Mr. H. A. Gebbie: "Semi-conductors as Optical Materials for the Infra-red"; Prof. R. W. Ditchburn and Mr. B. L. Ginsborg: "Involuntary Eye Movements".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Discussion on "The Thermodynamics of Elasticity in Biological Tissues" (to be opened by Prof. A. V. Hill, F.R.S.).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. H. Munro Fox, F.R.S.: "Respiratory Pigments". (Further Lectures on February 7 and 14.)

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Bernhard Katz: "Different Forms of Signalling Employed by the Nervous System" (Inaugural Lecture).*

COLLEGE OF PRECEPTORS (at 2 Bloomsbury Square, London, W.C.1), at 6 p.m.—Dr. Eric James: "The New Vision in the School" ("Horizons in the School", 3). (Joseph Payne Memorial Lectures.)*

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Prof. G. I. Finch, F.R.S.: "The Electron-Optical Study of Corrosion".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the BATTERSEA POLYTECHNIC CHEMICAL SOCIETY, at Battersea Polytechnic, Battersea, London, S.W.11), at 7 p.m.—Dr. J. B. Gardner: "The Separation of Gases by Low Temperature Methods".

BRITISH GLACIOLOGICAL SOCIETY (in the Department of Geography, Downing Place, Cambridge), at 8.15 p.m.—Mr. W. V. Lewis, Miss J. M. Clark, Mr. R. J. Adie and Mr. J. G. McCall: "The Internal Structure of a Glacier".

UNIVERSITY OF LONDON (at Wye College, Wye, Kent), at 8.15 p.m.—Dr. C. D. Darlington, F.R.S.: "The Coming of Genetics".*

Friday, February 1

TEXTILE INSTITUTE (at 16 St. Mary's Parsonage, Manchester), at 1 p.m.—Mr. W. S. Sondhelm: "Analysis, Testing and Grading of Cotton Fibres, Yarns and Fabrics".

PHYSICAL SOCIETY (in the Main Theatre, Physics Building, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Scientific Papers.

ROYAL INSTITUTE OF PHILOSOPHY (at University Hall, 14 Gordon Square, London, W.C.1), at 5.15 p.m.—Rev. F. C. Copleston: "The Function of Metaphysics".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN GEOLOGY (qualified to teach to an advanced stage in Stratigraphy and Palæontology)—The Registrar, University College, Singleton Park, Swansea (February 2).

DEPUTY CHIEF ENGINEER (Research) responsible to Chief Engineer for overall direction of research with object of improving efficiency of generation, transmission, distribution and utilization of electricity—The Director of Establishments, British Electricity Authority, British Electricity House, Great Portland Street, London, W.1, quoting A.E.226 (February 7).

CHIEF LABORATORY ENGINEER to take charge of a Highways Laboratory at Ossett, near Wakefield—The County Engineer and Surveyor, County Hall, Wakefield (February 9).

CHEMISTS for analytical investigational work in the Coal Survey Laboratories at Chester and Newcastle-upon-Tyne—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/416 and post applied for (February 16).

LECTURER IN PHILOSOPHY at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 22).

DIRECTOR OF THE CANTERBURY AGRICULTURAL COLLEGE (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 29).

SENIOR LECTURER IN APPLIED MATHEMATICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 3).

SENIOR LECTURERS IN ANIMAL HUSBANDRY, CIVIL ENGINEERING, PHARMACOLOGY, and LECTURERS IN AGRICULTURAL BOTANY, CIVIL ENGINEERING, MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, GEOGRAPHY (physical geography), VETERINARY ANATOMY, VETERINARY PATHOLOGY AND BACTERIOLOGY, VETERINARY PHYSIOLOGY, VETERINARY SURGERY AND OBSTETRICS, ARCHITECTURE, DENTISTRY, at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 3).

RESEARCH FELLOW IN ANTHROPOLOGY, and a RESEARCH FELLOW IN ECONOMICS, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 4).

ELECTRICAL INSPECTOR OF MINES AND QUARRIES, Ministry of Fuel and Power—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4118/52 (March 6).

PROFESSOR/READER IN MATHEMATICS—The Registrar, The University, University Buildings, Chepauk, Madras, India (March 12).

LECTURER IN PHYSIOLOGY—The Registrar, Queen's University, Belfast (March 30).

SENIOR LECTURER IN THE DEPARTMENT OF CHEMISTRY, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 31).

BIOLOGICAL SCHOLARSHIPS AND BURSARIES to enable graduates in the physical sciences, or in mathematics, to receive such training in biology as will enable them to undertake research and teaching in the United Kingdom in the biological sciences—The Secretary, Nuffield Foundation, 12–13 Mecklenburgh Square, London, W.C.1 (April 1).

I.C.I. FELLOWSHIPS in physics, chemistry, biochemistry, engineering, metallurgy, pharmacology, chemotherapy, or related subjects—The Secretary of the Board of Research Studies, The Old Schools, Cambridge (April 30).

SOCIOLOGICAL SCHOLARSHIPS AND BURSARIES to enable graduates in other academic subjects, especially science and mathematics, to transfer to the social sciences—The Secretary, Nuffield Foundation, 12–13 Mecklenburgh Square, London, W.C.1 (May 1).

ASSISTANT DIRECTOR (with honours degree in chemistry or corporate membership of the R.I.C. or I.C.E., administrative and technical management experience of the production of explosives and acids) by the Ministry of Supply in London, for the detailed control of all manufacturing activities of the Explosives Group of Royal Ordnance Factories, which includes propellants, high explosives and acids—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.33/52A.

BOTANISTS (2) to assist in the preparation of Flora of Tropical East Africa at the Royal Botanic Gardens, Kew—The Under-Secretary of State, Research Department (S.610), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

CHIEF MECHANICAL AND ELECTRICAL ENGINEER by the Directorate General of Municipalities, Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.24754.B.

ELECTRICAL ENGINEERS and PHYSICISTS at the Royal Aircraft Establishment, Farnborough: PRINCIPAL SCIENTIFIC OFFICER (Ref. D.501/51A) to act as Deputy Leader of a team engaged on the research and development of novel applications of radio techniques; SENIOR SCIENTIFIC OFFICER and SCIENTIFIC OFFICER (Ref. A.345/51A) to assist in various aspects of the work detailed above; SENIOR SCIENTIFIC OFFICER (Ref. A.346/51A) to work on novel forms of sighting equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

ELECTRICAL ENGINEERS AND PHYSICISTS (Scientific Officer grade) in the Instrument and Photographic Department of the Royal Aircraft Establishment, Farnborough: (Ref. A.347/51A) for the assessment of analogue computor and servomechanism techniques and the development of precision equipment in that field for use in aircraft; (Ref. A.348/51A) for the analysis of the complex dynamical problems arising in automatic control of aircraft and for research upon methods of control; (Ref. A.349/51A) for research and development work in connexion with gyroscopic and allied instruments; (Ref. A.350/51A) for the development of aircraft cameras, involving image movement compensation, exposure frequency control and gyroscopic stabilization —The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26–28 King Street, London, S.W.1, quoting the appropriate Ref. No.

EXECUTIVE ENGINEER IN THE DEPARTMENT OF RURAL WATER SUPPLY, Gold Coast—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27322/194.

EXPERIMENTAL OFFICERS at an R.A.F. Signals Experimental Station near London, for (*a*) the reconstruction of a radar landing aid and organization of associated experimental investigation, and (*b*) advice to R.A.F. and to contractors on associated problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.6/52A.

GRADUATE IN PHYSICAL SCIENCES, to undertake abstracting, report writing and other information duties—The Assistant Secretary, (Ref. A.45), British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

JUNIOR RESEARCH CHEMIST or BIOCHEMIST of graduate standing, in the Biological Chemotherapy Division, for work on antibiotics and bacterial chemistry—The Director, National Institute for Medical Research, Mill Hill, London, N.W.7.

LECTURER or ASSISTANT LECTURER IN CHEMISTRY (with special qualifications in inorganic chemistry)—The Secretary and Registrar, University College, Southampton.

PASTURE RESEARCH OFFICER (with a university degree in agriculture or botany) in the Sudan Veterinary Service—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1; or The Director, Sudan Veterinary Service, Khartoum, Sudan, endorsed 'Pasture Research Officer, 4/2201'.

PHYSICIST (with a first- or second-class honours degree in physics, associateship of the Institute of Physics, or equivalent qualifications) for production planning, to undertake studies relating to the operation of atomic piles and other novel plants—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 291.

PHYSICISTS at a Ministry of Supply Research Establishment in Berkshire, for work of a research and development character, concerned with the use of radioactive materials, radiation measurements and health physics—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.333/51A.

PHYSICISTS or CHEMISTS (Experimental Officer grade) at a Ministry of Supply Research Establishment in Southern England, for the supervision and running of a number of special instruments, including equipment for electrophoresis, ultra-sonics, ultra-centrifuge work and spectro-photometric equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.5/52A.

RESEARCH ASSISTANT to help with the development of electronic apparatus for medical purposes—The Dean, Guy's Hospital Medical School, London, S.E.1.

RESEARCH ASSISTANTS (Inter.B.Sc. standard, or equivalent)—The Printing, Packaging, and Allied Trades Research Association, Randalls Road, Leatherhead, Surrey.

RESEARCH ASSISTANTS (senior and junior) IN THE DEPARTMENT OF BIOCHEMISTRY—Prof. H. Raistrick, Biochemistry Department, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER, to assist in a development programme on the improvement of industrial gas producers as used for furnace firing—The Assistant Secretary (Ref. A.4), British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

SENIOR SCIENTIFIC OFFICERS (Ref. S.53/52), SCIENTIFIC OFFICERS, PATENT EXAMINERS and PATENT OFFICERS (Ref. S.52/52/S.128/52), in various Government Departments covering a wide range of scientific research and development in most of the major fields of fundamental and applied science (the Patent posts are in the Patent Office (Board of Trade), Admiralty and Ministry of Supply)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting the appropriate Ref. No.

SURVEYOR to take charge of a Provisional Cadastral Survey Office after preliminary field work, H.M. Colonial Service, Nigeria—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27076/13/51.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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